DETECTION, DETERMINATION AND SEPARATION OF ORGANIC AND INORGANIC SUBUSTANCES

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BY

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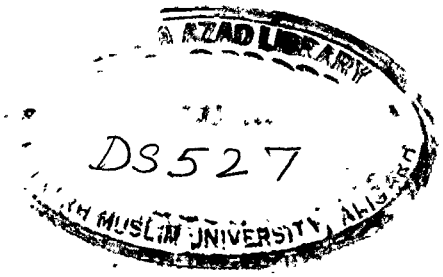

A C K N O W L E D G E M E N T

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INTRODUCTION

Analytical chemistry deals with the development of methods for chemical analysis which is indispensable in many branches of Science. Establishment of the mechanism of various reactions and formulation of the fundamental laws of Chemistry has largely been based on the results of Chemical Analysis. It finds a constant application in technology, industry, medicine, agriculture, geology, criminology and other fields. The chemical analysis is ordinarily divided into qualitative analysis and quantitative analysis. The qualitative analysis deals with the detection of constituents or components present in a compound or sample while quantitative analysis determines the proportions in which the constituents or the amounts of the constituents are present.

The constituents to be detected or determined may be from inorganic or organic substances and the analysis correspondingly known as Inorganic or Organic Analysis. Inorganic Analysis has been developed to establish, in many cases, important fundamental laws of theories of chemistry. Most of the reactions are straight forward and there is less probability of side reactions. The nature of inorganic substances is governed by a number of selective and specific reactions and, therefore, specificity and selectivity has been studied in greater detail.

Organic Analysis on the other hand, deals with the organic reactions which are usually slower involving more complex

mechanism and with greater probability of side reactions. Members of homologuous series show similar behaviour or compounds containing same functional group are more alike chemically, and therefore, the mixtures are more complex. However, currently the situation is improving and today, a large number of analytical chemists are occupied in the development of organic analysis.

Separation in most of the cases, is one of the important pretreatment method for qualitative and quantitative analysis. For an analysis some form of pretreatment of sample is usually required so as to remove interference of other substances. Separation, a versatile form of pretreatment, involves classical and modern techniques. The precipitation and distillation are the classical techniques and are replaced markedly by modern techniques as Chromatography, Solvent extraction, Ion-exchange and Electrophoresis. The rapid development of these modern techniques has increased the requirements placed in analytical laboratories. One of these chromatography is a practically important, simple and convenient method of separations.

Thus separations find an important position in chemical analysis while chromatography has proved itself to be a powerful tool to chemical separations. The wide scope of chromatography is the result of the labours of many, many people. It grew in response to practical needs.

The technique of chromatography was discovered by a Swedish Botanist, Michael Tswett (1) in 1906. Later on in 1910

he published a detailed monograph, "Chlorophylls in the plant and animal world". The different components of a pigment mixture were resolved in the form of various coloured zones on a simple calcium carbonate column. He described that the resolution is based on the adsorption mechanism. Since the component which is more strongly adsorbed on the column displaces the weaker adsorbed ones downwards. Kuhn & his coworkers (2,3) demonstrated the value of this new technique of adsorption chromatography and resolved plant carotine into several components.

Thereafter people were in persistent search for an adsorption chromatographic micro-separation process. In this course thin capillaries were tried in place of broader Tswett-columns. However, a success in this field was obtained by the development of 'Drop Chromatography' by Izmailov and Schraiber (4) in 1938 by the change of closed columns to open columns in the form of adsorbent coated glass plates and this may be considered as the historical start of thin layer chromatography. Meinhard and Hall (5) in 1948 added the use of binding agent to hold the layer in place and named the technique as 'Surface Chromatography'. A series of excellent papers were published by Kirchner et al. (6,7,8) using this method and the name "Chromatostrip technique" was employed. The most important contribution to the development of TLC was made by E.Stahl (9-18) by the use of fine grain and thiner sorption layers. Because of thin layers of very fine grained material he called the method as "Thin Layer Chromatography".

On such plates the concentration of the separated components in each spot area is higher than on coarse sorption layers used earlier. Using fine grains and thin layers it became possible to achieve separations at an ultra micro level. Thus E.Stahl is known as the 'pioneer' of this technique.

The very precise and serious type of work started from 1958. Although several other authors (19-34) have also contributed a lot in the development of this branch of chromatography.

At present, thin layer chromatography has proved to be highly sensitive for traces of materials. Preparation of thin layer plates is quite simple. An adsorbent (stationary phase) such as silica or alumina in the form of a slurry with or without a binder is spread as a thin layer of specified thickness (0.5-2 mm) on a glass plate. It is then allowed to dry and used for chromatography in the following way.

The sample solution is applied as a spot or a line at a centimetre from one end of thin layer plate and the solvent is allowed to evaporate. This end of the plate is then dipped into a suitable developing solvent (mobile phase) placed in a closed tank. The level of the developing solvent is kept below the line or spot of the sample. The developing solvent rises continuously upward because of capillary action. Although development of thin layer can be made through ascending, descending, horizontal or radial movement of the solvent. But ascending mode tends to minimize problems of channeling of the solvent flow.

The plates are taken out of the tank and the solvent rise is marked with pencil. After drying the plates are sprayed by a suitable detector to identify the various components. For individual components of the sample the migration rates are different due to difference in distribution co-efficients between stationary phase and the mobile phase and this results in the separation of zones of different components of the sample. The different rates are measured as the ratio of distances travelled by the solute and the solvent in terms of Retardation Factor (R_F). Where,

$$R_F = \frac{\text{Distance travelled by the centre of the zone of solute}}{\text{Distance travelled by the developing solvent}}$$

Thin Layer Chromatography sometimes is also known as 'planer' or 'open column' chromatography. This technique has got the advantage of (i) low cost, (ii) sensitivity, (iii) simplicity, (iv) speed, (v) unaffected by high temperatures, (vi) unaffected by aggressive spraying reagents, (vii) less diffusion of the spots, (viii) possibility for quantitative measurements, and (ix) a wide range of applicability in terms of adsorbent, developing solvents and the sample.

A large number of stationary phases have been applied, the most widely used being Silica, $SiO_2.X\ H_2O$, a polar adsorbent. Chromatographic silica typically has a surface area of about 500 m^2/gm, a pore volume of about 0.4 ml/gm, and an average pore

diameter of about 10 nm. Surface area may be decreased by aging in steam. Surface adsorption sites are composed of hydroxyl groups that are attached to silicon atoms and interact with adsorbing molecules through hydrogen bonding. The maximum concentration of these surface hydroxyl groups is obtained by heating to about 200°C, where most of the adsorbed water is removed. At higher temperatures, hydroxyl groups interact with each other to liberate water, and the surface activity decreases. Distinction is made between several types of hydroxyl groups e.g. Free, Bound, and Reactive. Reactive sites are presumed to be best for adsorption of polyfunctional solutes (the most common type) whereas monofunctional solutes adsorb equally will on reactive and free sites.

Next in importance to silica is Alumina, an adsorbent having basic sites. A problem with alumina is that Base-Catalyzed reactions may occur with many solutes, particularly when the alumina has been activated at a high temperature. Strong acid solutes may be chemisorbed, esters and anhydrides may saponify, aldehydes and ketones may form condensation products, double bond may change, double bonds may change position and hydrogen halide may be lost. Most commonly used is low-temperature (200°C), impure-γ-alumina with a surface area of 100 to 200 m^2/gm. It is usually assumed that oxide ions (O^{--}) are present in the surface layer and Aluminium ions (Al^{+++}) in the layer below. Water may be present as either hydroxyl groups or adsorbed water. Heating to about 300°C removes most of the adsorbed water and brings about

a reaction to form hydroxyl groups, which in turn can be removed by heating to about 800°C surface activity increases with temperature. At high temperature (1100°C) α -alumina is formed which has low surface area and is chromatographically inactive.

Alumina has been used as an adsorbent mainly in column chromatography, but it is not used to the same extent as silica gel for thin layer chromatography. The number of papers reporting the application of alumina in thin layer chromatography are far lower than those for silica gel.

Alumina may be of three types namely Alkaline, Neutral and Acid-washed alumina. It can be activated to different degrees. For the preparation of neutral alumina, commercial alumina is covered with distilled water and a slight excess of 0.5N HCl is added with stirring. After standing for an hour the liquid is decanted and the alumina repeatedly washed with distilled water until the washings are free from chloride ions. It is then dried at 100-150°C for at least 12 hours.

Phenols are hydroxy derivatives of aromatic hydrocarbons. The hydroxy derivatives of aromatic hydrocarbons in general may be divided into three classes namely Alcohols, Enols and Phenols.

Phenols are compounds in which a hydroxy group is attached directly to a benzene ring. They are much more acidic than alcohols. Phenols are very hydrophyllic compounds with varied acidity. Certain phenols have got the importance in medicines

as effective antiseptic, purfumes, toothpowders, and mouth washes.

The demands of phenols are constantly increasing in a number of chemical industries related to manufacture of dyes, disinfectants, antioxidents, preparations of explosives and plastics etc.

The separation of such an important class of compound is naturally important. The main problem encountered for the separation of phenols is the separation of structural isomers. The use of chromatography in general and thin layer chromatography in particular can be made for their separation.

The earlier work on Thin Layer Chromatography of Phenols is summarised in the following table I.

TABLE I

THIN LAYER CHROMATOGRAPHY OF PHENOLS

Adsorbent	Developer	Detector	No. of Phenols	Highlights	References
Gypsum powder suspension, Alumina or Silica gel etc.	-	-	-	A review of chromatographic methods of separations is given with emphasis on the thin layer technique.	(35)
Silica gel	AcOH:Dioxane: C_6H_6 (4:25:90) or AcOH:MeOH:C_6H_6 (4:8:45)	-	22 Phenols with R_F values	The separations were rapid.	(36)
Silica gel	C_6H_6:AcOH:H_2O (2:2:1)	Diazotized p-Nitroaniline and 0.1N NaOH	Mono-,di-,and trihydric phenols and their esters were separated.	Quantitative determination was made for phenol,guaiacol and catechol by spectrophotometrically.	(37)
Low activity Alumina (4.2% moisture content)	C_6H_6:MeOH (9:1) or (8:2) and $CHCl_3$:EtOAc (3:1)	Spots were revealed in iodine vapours or in ultraviolet light.	50 Phenols with their R_F values and colours are tabulated.	Diphenols were better separated than monophenols on Al_2O_3 than on silica gel layer. The method was useful for the identification of a single phenol and not for mixtures.	(38)

(Table I continued)

Adsorbent	Developer	Detector	No.of Phenols	Highlights	References
Polyamide impregnated glass powder thin layers	C_6H_6:MeOH:AcOH (80:13:7)	Detected by coupling on the plates to form azo dyes.	PhOH Pyrocatechol(I), Resorcinol(II), Pyrogallol(III), and Phloroglucinol(IV).	Thin Layers were obtained by mixing 0.45 gm starch or CM-cellulose with 35 ml water until a translucent solution was obtained. 15 gm glass powder impregnated with polymide was added. R_F values were- PhOH (0.80), I (0.54), II (0.31), III (0.19), IV (0.02).	(39)
Silica gel G-K_2CO_3 plates	3 Solvent systems	Fast Blue salt BB (I)	9 Phenols	Separation of phenols, cresols, dimethyl phenols and naphthols were achieved.	(40)
Silica gel G	C_6H_6, BuOAc, and BuOAc:C_6H_6 (1:9)	-	Phenol, isomeric cresols, 3,4-, 3,5-, and 2,5-dimethyl phenol and 1- and 2-naphthols.	Separation was made after reaction with 1-Phenyl-2,3-dimethyl-4-amino-5-pyrozolone and after formation of azo dyes.	(41)
Silica gel G	CH_2Cl_2:Cyclohexane (55:45)	Fast Red salt AL (Stablized form of anthraquinone-1-diazonium chloride	-	In this solvent free phenols geve better separation except for isomeric cresols.	(42)

(Table I continued)

Adsorbent	Developer	Detector	No.of Phenols	Highlights	References
Micropolyamide plates	C_6H_6:MeOH: AcOH (45:8:4)	Diazotized Benzidine	36 Phenolic compounds.	Phenolics from cigarette smoke condensate were also separated by TLC	(43)
Siliga gel G impregnated with anilinium chloride	C_6H_6:EtOAc (1:1),(3:1) or (9:1)	5% solution of $NaNO_2$	Various phenols.	Detection limit was 2 ug. Similar results were obtained by using sulphanilic acid hydrochloride.	(44)
Silica gel	CH_2Cl_2:EtOAc: Et_2NH (92:5:3) and $CHCl_3$:C_6H_6 (70:30)	Diazotised-4-benzoylamino-2,5-diethoxy-aniline (Fast Blue salt BB)	-	Isomeric cresols, Xylenols, and 1- and 2-naphthols were separated as coupling products.	(45)
20% Polyamide impregnated silica gel	C_6H_6:AcOH:MeOH (45:4:8)	Diazotized Sulphanilic acid followed by 10% NaOH solution.	Phenol,Pyro-catechol, Resorcinol, Pyrogallol, Phloroglucinol.	Orthogonal temperature gradient method was used. Mixture of 5 phenols were separated.	(46)
Silica gel	-	Aqueous 3% solution of SeO_2 and 1% solution of phenol in 20% Na_2CO_3	Various Amino-phenols.	Detection limits were 1-2 ug.	(47)

(Table I continued)

Adsorbent	Developer	Detector	No.of Phenols	Highlights	References
Cellulose	CH_2Cl_2:Cyclo-hexane (45:45)	Diazotized sulphanilic acid in 5% Na_2CO_3	(4).Phenol and isomeric methyl phenols.	The 7 isomers of dimethyl phenol and 1- and 2-naphthols do not interfere.	(48)
Commercial sheets impregnated with ammonium molybdate	1. $PhCH_3$, Me_2CO and $CHCl_3$ 2. C_6H_6 and Me_2CO	-	1. Dihydroxy phenols were separated. 2. Trihydroxy phenols were separated.	Separation and identification of polyphenols from a poly-monophenols mixtures. Mono-phenols gave light yellow spots but polyphenols gave dark green spots with naphthols as brown spots.	(49)
Silica gel G	$PhCH_3$:$CHCl_3$:Me_2CO (40:25:35) and C_6H_6:MeOH:AcOH (45:8:4)	Alkaline Chloramine T	-	Phenolic compounds were separated by TLC.	(50)
Silica gel G	C_6H_6:Me_2CO (9:1)	5% Chloramine T	Various phenols.	Semiquantitative determination.	(51)
and Cellulose	MeOH:$CHCl_3$ (9:1)	-do-		Limits of detection and determination (in ug) are tabulated for 41 compounds on both type of film supported plates.	

(Table I continued)

Adsorbent	Developer	Detector	No.of Phenols	Highlights	References
Polyamide	-Cyclodextrin (aqueous solution)	-	26 phenols. Phenols, substituted phenolic and naphtholic compounds.	R_F values depended on both structural features of the phenolic compounds and the concentration of -cyclodextrin in the mobile phase. O-, m-, and p-substituted phenols were separated.	(52)
Silica gel G impregnated with ethylene diamine, diethylene triamine, triethylene tetraamine and hexamine	-	-	Various Phenols.	A seperation scheme is given.	(53)

THIN LAYER CHROMATOGRAPHY OF PHENOLS ON ALUMINA (NEUTRAL)

A search of the literature shows that a number of adsorbents and varied classes of developers have been used for the separation of phenols. Most of the papers appear on silica gel as adsorbent. Use of Alumina has also been made but to a much lesser extent.

It was, therefore, decided to develop some simpler solvents to separate phenols on neutral alumina plates. A systematic chromatographic study has, therefore, been made with 24 developing solvent systems for 30 phenols of varied classes. The use of strong alkaline systems has been avoided as some of the phenols may oxidise in this medium and pose difficulty in detection. The results obtained on alumina are also compared with those obtained on silica gel plates.

EXPERIMENTAL

Apparatus

Thin layer chromatography apparatus (TOSHNIWAL, INDIA) was used for the preparation of plates. The chromatography was performed in 24 x 10 x 24 cm rectangular chamber with a lid.

Reagents

ALUMINA (NEUTRAL) for TLC of National Chemical Laboratory, Poona was used and Silica gel G for TLC (containing 13% calcium sulphate) of Biogen, Bombay was used.

Solutions of different Phenols of 0.1% concentration were prepared by dissolving 100 mg of each phenol in 100 ml of distilled alcohol.

Detector

Ferric chloride anhydrous (Laboratory Reagent) of Sarabhai M.Chemicals, India was used as 1% solution of it, prepared by dissolving 1 gm in 100 ml distilled alcohol.

Other chemicals and solvents were of analytical grade.

Developer

The following solvent systems were used as developers-

1. Conductivity water
2. Distilled alcohol

3. Ethyl acetate (B.D.H.)
4. Acetone (E.Merck)
5. 1,4-Dioxane (B.D.H.)
6. Methanol (B.D.H.)
7. Butanone-2 (B.D.H.)
8. Benzene (B.D.H.)
9. Carbon di sulphide (Koch light)
10. Dimethyl sulphoxide (Koch light)
11. Acetic acid (E.Merck)
12. Toluene (B.D.H.)
13. Pyridine (B.D.H.)
14. Ammonia (B.D.H.)
15. S D S (Koch light)
16. Aniline (B.D.H.)
17. Butanone-2 and Cyclohexane (1:3)
18. Acetic acid and 1,4-Dioxane (1:1)
19. Methanol and Toluene (1:1)
20. Toluene, Chloroform and Acetone (35:30:35)
21. n-Butanol, Benzene and Acetic acid (55:40:5).

Preparation Of Thin Layer Plates

(1) Silica gel G plates: The slurry of silica gel was prepared by mixing 24 gm silica gel in 48 ml of 1% starch solution (prepared by dissolving 1 gm starch in 100 ml conductivity water). This much slurry was sufficient for coating 3 plates of size 20 x 20 cm. The slurry was immediately coated on the clean glass plates with

the help of an applicator (Toshniwal,India) to give a layer of 0.50 mm thickness for qualitative studies. These plates were first dried at room temperature for complete drying and then stores in an oven at room temperature until used.

(ii) Alumina (neutral) plates: The slurry of alumina was also prepared by mixing alumina (neutral) 24 gm in 48 ml of 1% starch solution (as prepared above) with constant shaking for 5 minutes. This slurry was also sufficient for coating 3 plates of size 20 x 20 cm and thickness of the thin layer was also kept constant (0.50 mm). These were also dried as above and kept in an oven at room temperature until used. Uniformity of layer thickness was the important factor for optimum separations and reproducibility of R_F values.

Procedure

The plates were first activated by heating them at a temperature of 80-85°C for 15 minutes. Then one or two spots of the test solutions were placed with the help of fine glass capillaries and TLC Spotting Guide. The plates were then placed in a chamber which was saturated with desired solvent vapours. The solvent was allowed to ascend for a specified distance. Then the plates were removed from the chamber, dried and sprayed by alcoholic ferric chloride.

RESULTS

On detection a variety of colours were observed with different phenols which are listed as follows:

- Quinol, O-Cresol, m-Cresol, 8-Hydroxyquinoline, Quinhydrone, Catechol, α -Naphthol, B-Naphthol, 8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid and Phenyl Fluorone (9-phenyl-2,3,7-trihydroxy-6-fluorone) gave dark brown coloured spots.
- O-Nitrophenol and Picric acid gave yellow spots.
- Phenolphthaline gave pink coloured spot when followed by spray of KOH solution.
- Resorcinol, Vanilline, O-Aminophenol gave reddish-brown spots.
- Pyrogallol gave blackish spots.
- 1-Nitroso-2-Naphthol and Pentahydroxy flavone gave dark green spots.
- Bromo cresol green and Bromo phenol blue gave purple and violet colours respectively.
- m-Nitrophenol and p-Nitrophenol gave reddish-yellow spots.
- 4 (4-Nitrophenyl-azo)-resorcinol gave orange coloured spot.
- Thymol gave light grey spot.
- Phenol, Phloroglucinol, O-Chlorophenol and p-Chlorophenol gave reddish spots.

The results of R_f values in different solvent systems are shown in tables II, III and IV.

Separations

Separations were tried for the different phenols having differences in their R_f values. Spots of the mixtures were placed on the plates and developed with the desired developer. Those separations achieved practically are reported in tables V, VI and VII.

TABLE II

R_f VALUES OF 30 PHENOLS IN VARIOUS SOLVENT SYSTEMS

Sl. No.	Phenols	Conductivity water	EtOH	EtOAc (Pure)	Acetone (Pure)	1,4-Dioxane (Pure)
1.	O-Aminophenol	0.38	0.83	0.83	0.80	0.91
2.	O-Nitrophenol	0.65	0.27	0.40	0.09	0.18
3.	Resorcinol	0.70	0.77	0.43	0.52	0.48
4.	Catechol	0.05	0.03	0.02	0.02	0.02
5.	B.Naphthol	0.00	0.81	0.87	0.68	0.75
6.	Vanilline	0.50	0.36	0.20	0.08	0.19
7.	Thymol	0.00	0.84	0.88	0.12	0.93
8.	Phenol	0.00	0.80	0.84	0.08	0.83
9.	Picric acid	0.09	0.06	0.00	0.00	0.00
10.	m-Nitrophenol	0.52	0.68	0.27	0.19	0.19
11.	Quinol	0.73	0.70	0.52	0.66	0.57
12.	O-Cresol	0.00	0.83	0.00	0.87	0.70
13.	m-Cresol	0.00	0.85	-	0.87	0.90
14.	8-Hydroxy Quinoline	0.00	0.13	0.04	0.03	0.07
15.	O-Chlorophenol	0.00	0.02	0.03	0.00	0.00
16.	Pyrogallol	0.04	0.04	0.03	0.05	0.05
17.	Gallic acid	0.02	0.00	0.00	0.00	0.00
18.	p-Nitrophenol	0.43	0.43	0.22	0.18	0.27
19.	Phloroglucinol	0.71	0.34	0.11	0.22	0.20
20.	1-Nitroso-2-Naphthol	0.04	0.80	0.03	0.94	0.04
21.	α -Naphthol	0.51	0.81	0.79	0.88	0.80
22.	Bromo cresol green	0.00	0.00	0.00	0.00	0.00
23.	Bromo phenol blue	0.00	0.00	0.00	0.00	0.00
24.	Phenolphthaline	0.12	0.76	0.26	0.22	0.30
25.	Quinhydrone	0.78	0.78	0.77	0.64	0.64
26.	p-Chlorophenol	0.22	0.76	0.88	0.74	0.77
27.	4(4-Nitrophenyl azo) Resorcinol	0.00	0.23	0.87	0.00	0.02
28.	Pentahydroxy flavone	0.00	0.00	0.00	0.00	0.00
29.	8-Hydroxy-7-Iodoquinoline-5-sulphonic acid	0.00	0.00	0.00	0.00	0.00
30.	Phenyl Fluorone	0.00	0.00	0.00	0.00	0.00

(Table II continued)

Sl. No.	Phenols	Methanol (Pure)	Butanone (Pure)	Benzene (Pure)	CS_2 (Pure)	Toluene (Pure)
1.	O-Aminophenol	0.85	0.73	0.04	0.00	0.00
2.	O-Nitrophenol	0.16	0.06	0.11	0.03	0.05
3.	Resorcinol	0.74	0.29	0.00	0.00	0.03
4.	Catechol	0.03	0.02	0.00	0.00	0.00
5.	B-Naphthol	0.81	0.62	0.09	0.04	0.05
6.	Vanilline	0.18	0.06	0.04	0.00	0.00
7.	Thymol	0.88	0.90	0.42	0.09	0.24
8.	Phenol	0.84	0.75	0.13	0.11	0.09
9.	Picric acid	0.00	0.00	0.00	0.00	0.00
10.	m-Nitrophenol	0.57	0.28	0.00	0.00	0.04
11.	Quinol	0.81	0.66	0.00	0.00	0.00
12.	O-Cresol	0.88	0.88	0.18	0.13	0.16
13.	m-Cresol	0.87	0.89	0.16	0.06	0.10
14.	8-Hydroxy Quinoline	0.03	0.03	0.00	0.00	0.00
15.	O-Chlorophenol	0.77	0.74	0.00	0.09	0.09
16.	Pyrogallol	0.04	0.03	0.00	0.00	0.00
17.	Gallic acid	0.02	0.00	0.00	0.00	0.00
18.	p-Nitrophenol	0.23	0.20	0.03	0.00	0.03
19.	Phloroglucinol	0.40	0.13	0.00	0.00	0.00
20.	1-Nitroso-2-Naphthol	0.00	0.00	0.00	0.00	0.00
21.	α-Naphthol	0.72	0.81	0.04	0.00	0.04
22.	Bromo cresol green	0.00	0.00	0.00	0.00	0.00
23.	Bromo phenol blue	0.00	0.00	0.00	0.00	0.00
24.	Phenolphthaline	0.44	0.11	0.00	0.00	0.00
25.	Quinhydrone	0.62	0.00	0.00	0.00	0.00
26.	p-Chlorophenol	0.66	0.44	0.16	0.10	0.21
27.	4(4-Nitrophenyl azo) Resorcinol	0.02	0.00	0.00	0.00	0.00
28.	3,5,7,2,4,Pentahydroxy flavone	0.00	0.00	0.00	0.00	0.00
29.	8-Hydroxy-7-Iodoquino-line-5-sulphonic acid	0.00	0.00	0.00	0.00	0.00
30.	Phenyl Fluorone or (9-Phenyl-2,3,7-trihy-droxy-6-fluorone)	0.00	0.00	0.00	0.00	0.00

(Table II continued)

Sl. No.	Phenols	CH_3COOH 0.1M	DMSO 0.1M	Pyridine 0.1M	Pyridine 1.0M	SDS 1%	Aniline 0.1M
1.	O-Aminophenol	0.00	0.00	0.00	0.00	0.06	0.00
2.	O-Nitrophenol	0.62	0.36	-	-	0.55	0.58
3.	Resorcinol	0.77	0.75	0.67	0.74	0.77	0.75
4.	Catechol	0.14	0.04	0.03	0.04	0.06	0.02
5.	B-Naphthol	0.00	0.00	0.00	0.00	0.03	0.00
6.	Vanilline	0.54	0.43	0.48	0.63	0.73	0.62
7.	Thymol	0.00	0.00	0.00	0.00	0.60	-
8.	Phenol	0.00	0.00	0.00	0.03	0.41	-
9.	Picric acid	0.62	0.00	0.17	0.51	0.43	0.12
10.	m-Nitrophenol	0.56	0.54	0.58	0.46	0.54	0.52
11.	Quinol	0.76	0.76	0.78	0.75	0.74	0.34
12.	O-Cresol	0.00	0.00	0.00	0.00	0.00	0.00
13.	m-Cresol	0.00	0.00	0.00	0.00	0.00	0.00
14.	8-Hydroxy Quinoline	0.00	0.00	0.00	0.00	0.00	0.00
15.	O-Chlorophenol	0.00	0.00	0.00	0.08	0.62	0.00
16.	Pyrogallol	0.11	0.08	0.06	0.06	0.06	0.06
17.	Gallic acid	0.03	0.02	0.03	0.04	0.04	0.02
18.	p-Nitrophenol	0.33	0.27	0.22	0.18	0.38	0.27
19.	Phloroglucinol	0.68	0.67	0.62	0.65	0.36	0.38
20.	1-Nitroso-2-Naphthol	0.11	0.04	0.04	0.08	0.08	0.04
21.	α-Naphthol	0.00	0.00	0.00	0.00	0.32	0.00
22.	Bromo cresol green	0.30	0.50	0.13	0.38	0.38	0.04
23.	Bromo phenol blue	0.30	0.59	0.15	0.39	0.38	0.04
24.	Phenolphthaline	0.00	0.00	0.00	0.00	0.29	0.13
25.	Quinhydrone	0.73	0.80	0.76	0.77	0.76	0.00
26.	p-Chlorophenol	0.00	0.00	0.00	0.05	0.54	0.15
27.	4(4-Nitrophenyl azo) Resoreinol	0.00	0.00	0.00	0.54	0.23	0.20
28.	3,5,7,2,4-Pentahydroxy flavone	0.00	0.00	0.00	0.02	0.03	0.00
29.	8-Hydroxy-7-Iodoquino-line-5-sulphonic acid	0.00	0.00	0.02	0.03	0.06	0.00
30.	Phenyl Fluorone or (9-Phenyl-2,3,7-trihy-droxy-6-fluorone)	0.00	0.00	0.00	0.00	0.00	0.00

(Table II continued)

Sl. No.	Phenols	Butanone :Cyclo-hexane (1:3)	Toluene: Chloro-form: Acetone (35:30: 35)	Butanol: Benzene: Acetic acid (55:40: 5)	Toluene: Methanol (1:1)	0.1M AcOH: 1,4-Diox-ane (1:1)
1.	O-Aminophenol	0.34	0.75	0.92	0.80	0.92
2.	O-Nitrophenol	0.29	0.47	0.82	0.42	0.42
3.	Resorcinol	0.15	0.23	0.80	0.59	0.87
4.	Catechol	0.00	0.02	0.54	0.02	0.07
5.	B-Naphthol	0.42	0.74	0.92	0.64	0.91
6.	Vanilline	0.06	0.20	0.78	0.36	0.85
7.	Thymol	0.82	0.92	0.94	-	-
8.	Phenol	0.58	0.71	0.83	-	-
9.	Picric acid	0.00	0.00	0.05	0.05	-
10.	m-Nitrophenol	0.21	0.25	0.79	0.55	0.83
11.	Quinol	0.12	0.14	0.74	0.58	0.86
12.	O-Cresol	0.70	0.80	0.82	-	-
13.	m-Cresol	0.53	0.74	0.79	-	0.82
14.	8-Hydroxy Quinoline	0.03	0.02	0.19	0.05	0.08
15.	O-Chlorophenol	0.45	0.12	0.30	-	-
16.	Pyrogallol	0.03	0.04	0.20	0.03	0.09
17.	Gallic acid	0.00	0.00	0.07	0.02	0.04
18.	p-Nitrophenol	0.20	0.14	0.71	0.34	0.74
19.	Phloroglucinol	0.04	0.04	0.59	0.26	0.82
20.	1-Nitroso-2-Naphthol	0.03	0.06	0.60	0.09	0.10
21.	α -Naphthol	0.52	0.66	0.86	0.72	0.87
22.	Bromo cresol green	0.00	0.00	0.02	0.00	0.17
23.	Bromo phenol blue	0.00	0.00	0.02	0.00	0.16
24.	Phenolphthaline	0.04	0.14	0.86	0.54	0.94
25.	Quinhydrone	0.12	0.13	0.89	0.63	0.93
26.	p-Chlorophenol	0.46	0.55	0.90	0.71	0.85
27.	4(4-Nitrophenyl azo) Resorcinol	0.00	0.00	0.70	0.12	0.65
28.	3,5,7,2,4-Penthhydroxy flavone	0.00	0.00	0.07	0.00	0.04
29.	8-Hydroxy-7-Iodoquino-line-5-sulphonic acid	0.00	0.00	0.00	0.00	0.00
30.	Phenyl Fluorone or (9-Phenyl-2,3,7-trihy-droxy-6-fluorone)	0.00	0.00	0.00	0.00	0.00

TABLE III

R_f VALUES OF 30 PHENOLS ON SILICA GEL LAYER IN VARIOUS SOLVENT SYSTEMS

Sl. No.	Phenols	Ethyl acetate (Pure)	1,4-Dioxane (Pure)	Methanol (Pure)	Butan-one-2 (Pure)	Acetone (Pure)
1.	O-Aminophenol	0.94	0.93	0.88	0.83	0.90
2.	O-Nitrophenol	0.91	0.91	0.87	0.81	0.95
3.	Resorcinol	0.94	0.89	0.86	-	0.95
4.	Catechol	0.90	0.88	0.86	0.85	0.95
5.	B-Naphthol	0.92	0.89	0.88	0.88	0.95
6.	Vanilline	0.75	0.86	0.85	0.77	0.91
7.	Thymol	0.96	0.89	0.89	0.89	-
8.	Phenol	0.96	0.94	0.88	0.86	-
9.	Picric acid	0.57	0.60	0.96	0.78	0.94
10.	m-Nitrophenol	0.91	0.91	0.93	0.88	0.98
11.	Quinol	0.91	0.90	0.92	0.87	0.99
12.	O-Cresol	0.96	0.89	0.94	0.91	-
13.	m-Cresol	0.98	0.94	0.93	0.91	-
14.	8-Hydroxy Quinoline	0.85	0.91	0.90	0.82	0.86
15.	O-Chlorophenol	0.95	-	0.95	-	-
16.	Pyrogallol	0.75	0.90	0.92	0.68	0.97
17.	Gallic acid	0.03	0.09	0.74	0.10	0.08T

(Table III continued)

Sl. No.	Phenols	Ethyl acetate (Pure)	1,4-Dioxane (Pure)	Methanol (Pure)	Butan-one-2 (Pure)	Acetone (Pure)
18.	p-Nitrophenol	0.68	0.75	0.82	0.77	0.91
19.	Phloroglucinol	0.79	0.78	0.86	0.94	0.98
20.	1-Nitroso-2-naphthol	0.72	0.76	0.88	0.44	0.97
21.	α -Naphthol	0.92	0.85	0.92	0.95	0.97
22.	Bromo cresol green	0.00	0.03	0.92	0.03	0.09 T
23.	Bromo phenol blue	0.00	0.02	0.87	0.03	0.10 T
24.	Phenolphthaline	0.93	0.86	0.87	0.91	0.96
25.	Quinhydrone	0.00	0.98	0.96	0.92	0.95
26.	p-Chlorophenol	0.90	0.95	0.96	0.98	0.91
27.	4(4-Nitrophenyl azo) Resorcinol	0.16	0.82	0.96	0.07	0.18
28.	3,5,7,2,4-Pentahydroxy flavone	0.07	0.68	0.94	0.15	0.37 T
29.	8-Hydroxy-7-Iodoquino-line-5-sulphonic acid	0.00	0.02	0.94	0.00	0.03 T
30.	Phenyl Fluorone or (9-Phenyl-2,3,7-trihy-droxy-6-fluorone)	0.04	0.04	0.29	0.02	0.05 T

T = Tailing

TABLE IV

R_F VALUES OF 30 PHENOLS IN DIFF.CONCENTRATION OF AMMONIUM HYDROXIDE

Sl. No.	Phenols	0.01M NH_4OH	0.1M NH_4OH	1.0M NH_4OH
1.	O-Aminophenol	0.00	0.00	0.00
2.	O-Nitrophenol	0.71	0.79	0.84
3.	Resorcinol	0.65	0.69	0.75
4.	Catechol	0.03	0.04	0.05
5.	B-Naphthol	0.00	0.39	0.61
6.	Vanilline	0.68	0.78	0.82
7.	Thymol	0.00	0.00	0.00
8.	Phenol	0.00	0.00	0.00
9.	Picric acid	0.69	0.71	0.77
10.	m-Nitrophenol	0.60	0.75	0.77
11.	Quinol	0.27	0.30	0.35
12.	O-Cresol	0.00	0.00	0.00
13.	m-Cresol	0.00	0.00	0.00
14.	8-Hydroxy Quinoline	0.00	0.00	0.00
15.	O-Chlorophenol	0.00	0.00	0.00
16.	Pyrogallol	0.05	0.07	0.10
17.	Gallic Acid	0.03	0.06	0.08
18.	p-Nitrophenol	0.45	0.65	0.74
19.	Phloroglucinol	0.39	0.41	0.51
20.	1-Nitroso-2-Naphthol	0.34	0.45	0.56
21.	α-Naphthol	0.00	0.59	0.62
22.	Bromocresol green	0.45	0.76	0.80
23.	Bromophenol blue	0.49	0.78	0.83
24.	Phenolphthaline	0.28	0.50	0.57
25.	Quinhydrone	0.20	0.35	0.48
26.	p-Chlorophenol	0.17	0.33	0.39
27.	4(4-Nitrophenyl azo) Resorcinol	0.22	0.43	0.58
28.	3,5,7,2,4-Pentahydroxy flavone	0.02	0.12	0.18
29.	8-Hydroxy-7-Iodoquino-line-5-sulphonic acid	0.02	0.13	0.23
30.	Phenyl Fluorone or (9-Phenyl-2,3,7-trihy-droxy-6-fluorone)	0.00	0.00	0.00

TABLE V

BINARY SEPARATIONS ACHIEVED IN VARIOUS SOLVENT SYSTEMS

Sl. No.	Separation	
	Of R_F	From R_F
	SEPARATIONS IN CONDUCTIVITY WATER	
1.	O-Aminophenol (0.38)	O-Chlorophenol (0.00)
2.	O-Nitrophenol (0.00)	m-Nitrophenol (0.52)
3.	O-Nitrophenol (0.00)	p-Nitrophenol (0.43)
4.	Resorcinol (0.70)	Catechol (0.05)
5.	Resorcinol (0.70)	Pyrogallol (0.04)
6.	Resorcinol (0.70)	Gallic acid (0.02)
7.	Catechol (0.05)	Quinol (0.73)
8.	Catechol (0.05)	Phloroglucinol (0.71)
9.	B-Naphthol (0.00)	α-Naphthol (0.51)
10.	B-Naphthol (0.00)	Quinhydrone (0.78)
11.	Phenol (0.00)	m-Nitrophenol (0.52)
12.	Phenol (0.00)	Resorcinol (0.70)
13.	Phenol (0.00)	p-Nitrophenol (0.43)
14.	Phenol (0.00)	Phloroglucinol (0.71)
15.	Phenol (0.00)	Quinol (0.73)
16.	Vanilline (0.50)	Thymol (0.00)
17.	Vanilline (0.50)	Phenol (0.00)
18.	Picric acid (0.09)	m-Nitrophenol (0.52)
19.	Picric acid (0.09)	p-Nitrophenol (0.43)
20.	m-Nitrophenol (0.52)	O-Cresol (0.00)
21.	m-Nitrophenol (0.52)	m-Cresol (0.00)
22.	m-Nitrophenol (0.52)	1-Nitroso-2-Naphthol (0.04)
23.	Quinol (0.73)	Gallic acid (0.02)
24.	8-Hydroxy Quinoline (0.00)	Quinhydrone (0.78)
25.	8-Hydroxy Quinoline (0.00)	Quinol (0.73)
26.	Pyrogallol (0.04)	Phloroglucinol (0.71)
27.	Phloroglucinol (0.71)	Gallic acid (0.02)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
28.	1-Nitroso-2-Naphthol (0.04)	∝-Naphthol (0.51)
29.	1-Nitroso-2-Naphthol (0.04)	Quinhydrone (0.78)
30.	∝-Naphthol (0.51)	Quinhydrone (0.78)
31.	Quinhydrone (0.78)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)

SEPARATIONS IN ETHANOL

31.	O-Aminophenol (0.82)	O-Nitrophenol (0.26)
32.	O-Aminophenol (0.82)	O-Chlorophenol (0.02)
34.	O-Aminophenol (0.82)	p-Nitrophenol (0.43)
35.	O-Nitrophenol (0.27)	m-Nitrophenol (0.66)
36.	O-Nitrophenol (0.27)	Picric acid (0.06)
37.	Resorcinol (0.73)	Catechol (0.02)
38.	Resorcinol (0.73)	Pyrogallol (0.04)
39.	Resorcinol (0.73)	Phloroglucinol (0.34)
40.	Catechol (0.03)	Phenol (0.80)
41.	Catechol (0.03)	Quinol (0.80)
42.	Catechol (0.02)	Phloroglucinol (0.34)
43.	B-Naphthol (0.80)	8-Hydroxy Quinoline (0.13)
44.	Vanilline (0.35)	Thymol (0.84)
45.	Venilline (0.35)	Phenol (0.80)
46.	Thymol (0.84)	Bromocresol green (0.00)
47.	Thymol (0.84)	Bromo phenol blue (0.00)
48.	Phenol (0.80)	Picric acid (0.06)
49.	Phenol (0.80)	Pyrogallol (0.04)
50.	Phenol (0.80)	Phloroglucinol (0.34)
51.	Picric acid (0.06)	m-Nitrophenol (0.68)
52.	Picric acid (0.06)	p-Nitrophenol (0.43)
53.	m-Nitrophenol (0.65)	p-Nitrophenol (0.33)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
54.	Quinol (0.80)	Pyrogallol (0.04)
55.	Quinol (0.80)	Phloroglucinol (0.34)
56.	8-Hydroxy Quinoline (0.13)	Quinhydrone (0.78)
57.	Pyrogallol (0.04)	Phloroglucinol (0.34)
58.	Gallic acid (0.00)	Phloroglucinol (0.34)
59.	1-Nitroso-2-Naphthol (0.80)	8-Hydroxy Quinoline (0.13)
60.	1-Nitroso-2-Naphthol (0.80)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
61.	∝ -Naphthol (0.81)	8-Hydroxyquinoline (0.13)
62.	Bromocresol green (0.00)	Phenolphthaline (0.76)
63.	Bromophenol blue (0.00)	Phenolphthaline (0.76)
64.	Phenolphthaline (0.76)	4-(4-Nitrophenyl azo) Resorcinol (0.23)
65.	Phenolphthaline (0.76)	Phenyl Fluorone (0.00)
66.	Quinhydrone (0.78)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
67.	B-Naphthol (0.80)	Vanilline (0.35)
68.	4-(4-Nitrophenyl azo) Resorcinol (0.23)	Resorcinol (0.73)

SEPARATIONS IN ETHYL ACETATE

69.	O-Aminophenol (0.83)	O-Nitrophenol (0.40)
70.	O-Aminophenol (0.83)	p-Nitrophenol (0.22)
71.	O-Aminophenol (0.83)	m-Nitrophenol (0.27)
72.	O-Aminophenol (0.83)	O-Chlorophenol (0.03)
73.	Resorcinol (0.43)	Catechol (0.02)
74.	Resorcinol (0.43)	Pyrogallol (0.03)
75.	Resorcinol (0.43)	Phloroglucinol (0.11)
76.	Resorcinol (0.43)	Phenol (0.84)
77.	Catechol (0.02)	Phenol (0.84)
78.	Catechol (0.02)	Quinol (0.52)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
79.	B-Naphthol (0.87)	8-Hydroxyquinoline (0.04)
80.	B-Naphthol (0.87)	1-Nitroso-2-Naphthol (0.03)
81.	Resorcinol (0.43)	4-(4-Nitrophenyl azo) Resorcinol (0.87)
82.	Vanilline (0.20)	Thymol (0.88)
83.	Phenol (0.84)	Picric acid (0.00)
84.	Phenol (0.84)	O-Nitrophenol (0.40)
85.	Phenol (0.84)	m-Nitrophenol (0.27)
86.	Phenol (0.84)	p-Nitrophenol (0.22)
87.	Picric acid (0.00)	O-Nitrophenol (0.40)
88.	Picric acid (0.00)	m-Nitrophenol (0.27)
89.	Picric acid (0.00)	p-Nitrophenol (0.22)
90.	Quinol (0.52)	8-Hydroxyquinoline (0.04)
91.	Quinol (0.52)	Pyrogallol (0.03)
92.	Quinol (0.52)	Phloroglucinol (0.11)
93.	8-Hydroxyquinoline (0.04)	α-Naphthol (0.79)
94.	8-Hydroxyquinoline (0.04)	Quinhydrone (0.77)
95.	O-Chlorophenol (0.03)	p-Chlorophenol (0.88)
96.	p-Nitrophenol (0.22)	p-Chlorophenol (0.88)
97.	1-Nitroso-2-Naphthol (0.03)	α-Naphthol (0.79)
98.	1-Nitroso-2-Naphthol (0.03)	B-Naphthol (0.87)
99.	Bromo cresol green (0.00)	Phenolphthaline (0.26)
100.	Bromo phenol blue (0.00)	Phenolphthaline (0.27)
101.	Phenolphthaline (0.26)	Pentahydroxy flavone (0.00)
102.	Phenolphthaline (0.26)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
103.	Phenolphthaline (0.26)	Phenyl fluorone (0.00)

SEPARATIONS IN ACETONE

104.	O-Aminophenol (0.80)	O-Nitrophenol (0.09)
105.	O-Aminophenol (0.80)	m-Nitrophenol (0.19)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
106.	O-Aminophenol (0.80)	p-Nitrophenol (0.18)
107.	O-Aminophenol (0.80)	O-Chlorophenol (0.00)
108.	O-Nitrophenol (0.09)	p-Chlorophenol (0.74)
109.	Resorcinol (0.52)	Catechol (0.02)
110.	Resorcinol (0.52)	4-(4-Nitrophenyl azo) Resorcinol (0.00)
111.	Resorcinol (0.52)	Pyrogallol (0.05)
112.	Resorcinol (0.52)	Phloroglucinol (0.22)
113.	Catechol (0.02)	Phloroglucinol (0.23)
114.	B-Naphthol (0.67)	α-Naphthol (0.89)
115.	B-Naphthol (0.68)	8-Hydroxyquinoline (0.03)
116.	B-Naphthol (0.67)	1-Nitroso-2-Naphthol (0.94)
117.	Phenol (0.08)	p-Chlorophenol (0.74)
118.	Phenol (0.08)	α-Naphthol (0.89)
119.	Phenol (0.08)	B-Naphthol (0.67)
120.	Quinol (0.66)	Catechol (0.02)
121.	Quinol (0.66)	Pyrogallol (0.05)
122.	O-Chlorophenol (0.00)	p-Chlorophenol (0.74)
123.	Phloroglucinol (0.22)	Quinol (0.66)
124.	Quinhydrone (0.64)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
125.	Quinhydrone (0.64)	8-Hydroxyquinoline (0.03)
126.	Phenolphthaline (0.22)	Bromo cresol green (0.00)
127.	Phenolphthaline (0.22)	Bromo phenol blue (0.00)
128.	Phenolphthaline (0.22)	Phenyl fluorone (0.00)
129.	Phenolphthaline (0.22)	Penta hydroxy flavone (0.00)
	SEPARATIONS IN 1,4-DIOXANE	
130.	O-Aminophenol (0.91)	O-Nitrophenol (0.18)
131.	O-Aminophenol (0.91)	m-Nitrophenol (0.19)
132.	O-Aminophenol (0.91)	p-Nitrophenol (0.27)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
133.	O-Aminophenol (0.91)	O-Chlorophenol (0.00)
134.	O-Nitrophenol (0.18)	Phenol (0.83)
135.	Resorcinol (0.48)	Catechol (0.02)
136.	Resorcinol (0.48)	Phenol (0.83)
137.	Resorcinol (0.48)	Pyrogallol (0.05)
138.	Resorcinol (0.48)	Phloroglucinol (0.20)
139.	Resorcinol (0.48)	4-(4-Nitrophenyl azo) Resorcinol (0.02)
140.	Catechol (0.02)	Phenol (0.83)
141.	Catechol (0.02)	Quinol (0.57)
142.	B-Naphthol (0.75)	8-Hydroxyquinoline (0.07)
143.	B-Naphthol (0.75)	1-Nitroso-2-Naphthol (0.04)
144.	B-Naphthol (0.75)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
145.	Vanilline (0.19)	Thymol (0.93)
146.	Vanilline (0.19)	O-Cresol (0.70)
147.	Vanilline (0.19)	m-Cresol (0.90)
148.	Thymol (0.93)	Phenolphthaline (0.30)
149.	Thymol (0.93)	4-(4-Nitrophenyl azo) Resorcinol (0.02)
150.	Thymol (0.93)	Pentahydroxy flavone (0.00)
151.	Thymol (0.93)	Phenyl fluorone (0.00)
152.	Phenol (0.83)	Pyrogallol (0.05)
153.	Phenol (0.83)	Phloroglucinol (0.20)
154.	Phenol (0.81)	m-Nitrophenol (0.19)
155.	Phenol (0.81)	p-Nitrophenol (0.27)
156.	Phenol (0.82)	O-Nitrophenol (0.18)
157.	Phenol (0.83)	Gallic acid (0.00)
158.	Phenol (0.83)	Quinol (0.57)
159.	Picric acid (0.00)	p-Nitrophenol (0.27)
160.	m-Nitrophenol (0.19)	p-Chlorophenol (0.77)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
161.	Quinol (0.57)	Pyrogallol (0.05)
162.	Quinol (0.57)	Phloroglucinol (0.20)
163.	Quinol (0.57)	Gallic acid (0.00)
164.	O-Cresol (0.68)	m-Cresol (0.91)
165.	8-Hydroxyquinoline (0.07)	Quinhydrone (0.64)
166.	8-Hydroxyquinoline (0.07)	α-Naphthol (0.80)
167.	Gallic acid (0.00)	Resorcinol (0.48)
168.	p-Nitrophenol (0.27)	p-Chlorophenol (0.77)
169.	1-Nitroso-2-Naphthol (0.04)	α-Naphthol (0.80)
170.	1-Nitroso-2-Naphthol (0.04)	Quinhydrone (0.64)
171.	α-Naphthol (0.80)	8-Hydroxyquinoline (0.03)
172.	Bromo cresol green (0.00)	Phenolphthaline (0.30)
173.	Bromo phenol blue (0.00)	Phenolphthaline (0.31)
174.	Phenolphthaline (0.30)	4-(4-Nitrophenyl azo) Resorcinol (0.02)
175.	Phenolphthaline (0.30)	Pentahydroxy flavone (0.00)
176.	Phenolphthaline (0.30)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
177.	Phenolphthaline (0.30)	Phenyl fluorone (0.00)

SEPARATIONS ACHIEVED IN METHANOL

178.	O-Aminophenol (0.85)	O-Nitrophenol (0.16)
179.	O-Aminophenol (0.85)	m-Nitrophenol (0.57)
180.	O-Aminophenol (0.85)	p-Nitrophenol (0.23)
181.	O-Nitrophenol (0.16)	Phenol (0.84)
182.	O-Nitrophenol (0.16)	m-Nitrophenol (0.57)
183.	O-Nitrophenol (0.16)	O-Chlorophenol (0.77)
184.	Resorcinol (0.74)	Catechol (0.03)
185.	Resorcinol (0.74)	Pyrogallol (0.04)
186.	Resorcinol (0.74)	Phloroglucinol (0.40)
187.	Catechol (0.03)	Phenol (0.84)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
188.	Catechol (0.03)	Quinol (0.81)
189.	Catechol (0.03)	Phloroglucinol (0.40)
190.	B-Naphthol (0.81)	8-Hydroxy quinoline (0.03)
191.	B-Naphthol (0.81)	1-Nitroso-2-Naphthol (0.00)
192.	Resorcinol (0.74)	4-(4-Nitrophenyl azo) Resorcinol (0.02)
193.	Vanilline (0.18)	Thymol (0.88)
194.	Thymol (0.88)	Bromo cresol green (0.00)
195.	Thymol (0.88)	Bromo phenol blue (0.00)
196.	Tymol (0.88)	Phenolphthaline (0.44)
197.	Phenol (0.84)	Picric acid (0.11)
198.	Phenol (0.84)	O-Nitrophenol (0.16)
199.	Phenol (0.84)	m-Nitrophenol (0.57)
200.	Phenol (0.84)	p-Nitrophenol (0.23)
201.	m-Nitrophenol (0.57)	p-Nitrophenol (0.23)
202.	m-Nitrophenol (0.57)	O-Nitrophenol (0.16)
203.	Quinol (0.81)	Pyrogallol (0.04)
204.	Quinol (0.81)	Phloroglucinol (0.41)
205.	Quinol (0.80)	Gallic acid (0.02)
206.	O-Cresol (0.88)	Bromo cresol green (0.00)
207.	m-Cresol (0.87)	Bromo cresol green (0.00)
208.	8-Hydroxy quinoline (0.03)	α -Naphthol (0.72)
209.	O-Chlorophenol (0.77)	Gallic acid (0.00)
210.	Pyrogallol (0.04)	Phloroglucinol (0.40)
211.	Gallic acid (0.02)	Phloroglucinol (0.40)
212.	p-Nitrophenol (0.23)	p-Chlorophenol (0.66)
213.	1-Nitroso-2-Naphthol (0.00)	α -Naphthol (0.72)
214.	1-Nitroso-2-Naphthol (0.00)	Quinhydrone (0.62)
215.	1-Nitroso-2-Naphthol (0.02)	α -Naphthol (0.72)
216.	Bromo cresol green (0.00)	Phenolphthaline (0.44)
217.	Bromo phenol blue (0.00)	Phenolphthaline (0.44)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
218.	Quinhydrone (0.62)	8-Hydroxyquinoline (0.03)
219.	Quinhydrone (0.62)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
220.	4-(4-Nitrophenyl azo) Resorcinol (0.02)	Thymol (0.88)
221.	Pentahydroxy flavone (0.00)	Thymol (0.88)
222.	Phenyl fluorone (0.00)	Thymol (0.87)
	SEPARATIONS IN BUTANONE-2	
223.	O-Aminophenol (0.73)	O-Nitrophenol (0.06)
224.	O-Aminophenol (0.73)	m-Nitrophenol (0.28)
225.	O-Aminophenol (0.73)	p-Nitrophenol (0.20)
226.	Resorcinol (0.29)	Catechol (0.02)
227.	Resorcinol (0.29)	Phenol (0.75)
228.	Resorcinol (0.29)	Quinol (0.66)
229.	Resorcinol (0.29)	Pyrogallol (0.03)
230.	Resorcinol (0.29)	4-(4-Nitrophenyl azo) Resorcinol (0.00)
231.	Catechol (0.02)	Phenol (0.75)
232.	Catechol (0.02)	Quinol (0.66)
233.	B-Naphthol (0.62)	α-Naphthol (0.81)
234.	B-Naphthol (0.62)	8-Hydroxyquinoline (0.03)
235.	B-Naphthol (0.62)	1-Nitroso-2-Naphthol (0.00)
236.	B-Naphthol (0.62)	Quinhydrone (0.00)
237.	Vanilline (0.06)	Thymol (0.90)
238.	Thymol (0.90)	Bromo cresol green (0.00)
239.	Thymol (0.90)	Bromo phenol blue (0.00)
240.	Thymol (0.90)	Phenolphthaline (0.11)
241.	Pentahydroxy flavone (0.00)	Thymol (0.90)
242.	Phenyl fluorone (0.00)	Thymol (0.90)
243.	Phenol (0.84)	Nitrophenol (0.28)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
244.	Phenol (0.83)	p-Nitrophenol (0.20)
245.	Picric acid (0.11)	Phenol (0.74)
246.	m-Nitrophenol (0.28)	O-Nitrophenol (0.06)
247.	Quinol (0.66)	Pyrogallol (0.03)
248.	Quinol (0.66)	Phloroglucinol (0.13)
249.	m-Cresol (0.89)	Vanilline (0.06)
250.	8-Hydroxyquinoline (0.03)	α-Naphthol (0.81)
251.	8-Hydroxyquinoline (0.03)	B-Naphthol (0.62)
252.	O-Chlorophenol (0.74)	O-Nitrophenol (0.06)
253.	O-Chlorophenol (0.74)	p-Chlorophenol (0.44)
254.	1-Nitroso-2-Naphthol (0.00)	α-Naphthol (0.81)
255.	Gallic acid (0.00)	Quinol (0.67)
256.	Catechol (0.00)	B-Naphthol (0.62)
257.	Picric acid (0.00)	Quinol (0.66)
258.	α-Naphthol (0.81)	Bromo cresol green (0.00)
259.	α-Naphthol (0.81)	Bromo phenol blue (0.00)
260.	m-Cresol (0.88)	p-Nitrophenol (0.11)
261.	Catechol (0.00)	α-Naphthol (0.80)
	SEPARATIONS IN .1M PYRIDINE	
262.	O-Aminophenol (0.00)	m-Nitrophenol (0.46)
263.	Resorcinol (0.74)	Catechol (0.04)
264.	Resorcinol (0.74)	Pyrogallol (0.06)
265.	Catechol (0.04)	Phloroglucinol (0.65)
266.	Catechol (0.04)	Quinhydrone (0.76)
267.	B-Naphthol (0.00)	Quinhydrone (0.76)
268.	4-(4-Nitrophenyl azo) Resorcinol (0.54)	Resorcinol (0.74)
269.	Vanilline (0.63)	Thymol (0.00)
270.	Thymol (0.00)	Bromocresol green (0.38)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
271.	Thymol (0.00)	Bromo phenol blue (0.39)
272.	Thymol (0.00)	4-(4-Nitrophenyl azo) Resorcinol (0.54)
273.	Phenol (0.03)	Quinol (0.75)
274.	Phenol (0.03)	Resorcinol (0.74)
275.	Picric acid (0.51)	p-Nitrophenol (0.18)
276.	m-Nitrophenol (0.46)	p-Nitrophenol (0.18)
277.	Quinol (0.75)	Pyrogallol (0.06)
278.	Quinol (0.75)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.03)
279.	O-Cresol (0.00)	Vanilline (0.63)
280.	8-Hydroxyquinoline (0.00)	Quinhydrone (0.77)
281.	Pyrogallol (0.06)	Phloroglucinol (0.65)
282.	Phloroglucinol (0.65)	Gallic acid (0.04)
283.	1-Nitroso-2-Naphthol (0.08)	4-(4-Nitrophenyl azo) Resorcinol (0.54)
284.	Phenolphthaline (0.00)	Bromo cresol green (0.38)
285.	Phenolphthaline (0.00)	Bromo phenol blue (0.39)
286.	4-(4-Nitrophenyl azo) Resorcinol (0.54)	Phenolphthaline (0.00)
287.	-do-	Pentahydroxy flavone (0.02)
288.	-do-	Phenyl fluorone (0.00)
289.	-do-	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.03)

SEPARATIONS IN 0.1M PYRIDINE

290.	O-Aminophenol (0.00)	m-Nitrophenol (0.58)
291.	O-Aminophenol (0.00)	Quinol (0.78)
292.	Resorcinol (0.67)	Catechol (0.03)
293.	Resorcinol (0.67)	Pyrogallol (0.06)
294.	Catechol (0.03)	Phloroglucinol (0.62)
295.	Catechol (0.03)	Quinol (0.78)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
296.	Thymol (0.00)	Vanilline (0.48)
297.	Phenol (0.00)	Quinol (0.78)
298.	Resorcinol (0.67)	Vanilline (0.47)
299.	Picric acid (0.17)	m-Nitrophenol (0.58)
300.	m-Nitrophenol (0.58)	p-Nitrophenol (0.22)
301.	Quinol (0.78)	Pyrogallol (0.06)
302.	Pyrogallol (0.06)	Phloroglucinol (0.62)
303.	Gallic acid (0.03)	Phloroglucinol (0.61)
304.	Quinhydrone (0.76)	B-Naphthol (0.00)
305.	Quinhydrone (0.76)	α-Naphthol (0.00)
306.	Quinhydrone (0.76)	8-Hydroxyquinoline (0.00)
307.	Quinhydrone (0.74)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.02)
	SEPARATIONS IN 0.1M ACETIC ACID	
308.	O-Aminophenol (0.00)	O-Nitrophenol (0.62)
309.	O-Aminophenol (0.00)	m-Nitrophenol (0.56)
310.	O-Aminophenol (0.00)	p-Nitrophenol (0.33)
311.	O-Nitrophenol (0.62)	p-Nitrophenol (0.33)
312.	Resorcinol (0.77)	Catechol (0.14)
313.	Resorcinol (0.77)	Pyrogallol (0.11)
314.	Catechol (0.11)	Quinol (0.76)
315.	Catechol (0.11)	Phloroglucinol (0.68)
316.	Phenol (0.00)	Resorcinol (0.77)
317.	Phenol (0.00)	Quinol (0.76)
318.	Phenol (0.00)	Phloroglucinol (0.68)
319.	Picric acid (0.62)	p-Nitrophenol (0.33)
320.	m-Nitrophenol (0.56)	p-Nitrophenol (0.33)
321.	Quinol (0.76)	Gallic acid (0.03)
322.	Phloroglucinol (0.68)	Pyrogallol (0.11)
323.	Phloroglucinol (0.68)	Gallic acid (0.03)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
324.	Quinhydrone (0.73)	8-Hydroxyquinoline (0.00)
325.	Quinhydrone (0.73)	α-Naphthol (0.00)
326.	Quinhydrone (0.73)	B-Naphthol (0.00)
327.	Quinhydrone (0.73)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)
	SEPARATIONS IN 0.1M DMSO	
328.	O-Aminophenol (0.00)	O-Nitrophenol (0.36)
329.	O-Aminophenol (0.00)	m-Nitrophenol (0.54)
330.	O-Aminophenol (0.00)	p-Nitrophenol (0.27)
331.	Resorcinol (0.75)	Catechol (0.04)
332.	Resorcinol (0.75)	Pyrogallol (0.08)
333.	Catechol (0.04)	Quinol (0.76)
334.	Catechol (0.04)	Phloroglucinol (0.67)
335.	O-Cresol (0.00)	Vanilline (0.43)
336.	m-Cresol (0.00)	Vanilline (0.43)
337.	Phenol (0.00)	O-Nitrophenol (0.36)
338.	Phenol (0.00)	m-Nitrophenol (0.54)
339.	Phenol (0.00)	p-Nitrophenol (0.27)
340.	Phenol (0.00)	Resorcinol (0.75)
341.	Phenol (0.00)	Phloroglucinol (0.67)
342.	Picric acid (0.00)	O-Nitrophenol (0.36)
343.	Picric acid (0.00)	m-Nitrophenol (0.54)
344.	Picric acid (0.00)	p-Nitrophenol (0.27)
345.	m-Nitrophenol (0.54)	p-Nitrophenol (0.27)
346.	Quinol (0.76)	Pyrogallol (0.08)
347.	Pyrogallol (0.08)	Phloroglucinol (0.67)
348.	Gallic acid (0.02)	Phloroglucinol (0.67)
349.	Quinhydrone (0.80)	α-Naphthol (0.00)
350.	Quinhydrone (0.80)	B-Naphthol (0.00)
351.	Quinhydrone (0.80)	8-Hydroxyquinoline (0.00)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
352.	Quinhydrone (0.80)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)

SEPARATIONS IN 0.1M ANILINE

353.	O-Aminophenol (0.00)	m-Nitrophenol (0.52)
354.	O-Aminophenol (0.00)	p-Nitrophenol (0.27)
355.	O-Nitrophenol (0.58)	p-Nitrophenol (0.27)
356.	Resorcinol (0.75)	Catechol (0.02)
357.	Resorcinol (0.75)	Quinol (0.34)
358.	Resorcinol (0.75)	Pyrogallol (0.06)
359.	Resorcinol (0.75)	Phloroglucinol (0.38)
360.	Catechol (0.02)	Quinol (0.34)
361.	Catechol (0.02)	Phloroglucinol (0.38)
362.	Vanilline (0.62)	Picric acid (0.12)
363.	m-Nitrophenol (0.52)	p-Nitrophenol (0.27)
364.	Quinol (0.34)	Pyrogallol (0.06)
365.	Quinol (0.34)	Catechol (0.02)
366.	Quinol (0.34)	Gallic acid (0.02)
367.	Pyrogallol (0.06)	Vanilline (0.62)
368.	Gallic acid (0.02)	Vanilline (0.62)
369.	Phloroglucinol (0.38)	Pyrogallol (0.06)
370.	Resorcinol (0.75)	4-(4-Nitrophenyl azo) Resorcinol (0.20)
371.	Catechol (0.02)	Vanilline (0.62)

SEPARATIONS IN 1% SDS

372.	O-Aminophenol (0.06)	O-Nitrophenol (0.55)
373.	O-Aminophenol (0.06)	m-Nitrophenol (0.54)
374.	O-Aminophenol (0.06)	p-Nitrophenol (0.38)
375.	Resorcinol (0.77)	Catechol (0.06)
376.	Resorcinol (0.77)	Pyrogallol (0.06)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
377.	Resorcinol (0.77)	Phloroglucinol (0.36)
378.	Catechol (0.06)	Quinol (0.74)
379.	B-Naphthol (0.03)	Quinhydrone (0.76)
380.	Vanilline (0.73)	O-Cresol (0.00)
381.	Vanilline (0.73)	m-Cresol (0.00)
382.	Thymol (0.60)	Phenolphthaline (0.29)
383.	Picric acid (0.43)	Gallic acid (0.04)
384.	m-Nitrophenol (0.54)	Gallic acid (0.04)
385.	Quinol (0.74)	Pyrogallol (0.06)
386.	Quinol (0.74)	Phloroglucinol (0.36)
387.	Quinhydrone (0.76)	α -Naphthol (0.31)
388.	Quinhydrone (0.76)	8-Hydroxyquinoline (0.00)
389.	Quinhydrone (0.76)	1-Nitroso-2-Naphthol (0.08)

SEPARATIONS IN BUTANONE-2: CYCLOHEXANE (25:75)

390.	O-Aminophenol (0.34)	Catechol (0.00)
391.	Resorcinol (0.15)	Phenol (0.58)
392.	B-Naphthol (0.42)	8-Hydroxyquinoline (0.03)
393.	B-Naphthol (0.42)	1-Nitroso-2-Naphthol (0.03)
394.	B-Naphthol (0.42)	Quinhydrone (0.12)
395.	Vanilline (0.06)	Thymol (0.82)
396.	Vanilline (0.06)	O-Cresol (0.70)
397.	Vanilline (0.06)	m-Cresol (0.53)
398.	Thymol (0.82)	Phenolphthaline (0.04)
399.	Bromo cresol green (0.00)	Thymol (0.82)
400.	Bromo phenol blue (0.00)	Thymol (0.82)
401.	Phenol (0.58)	O-Nitrophenol (0.29)
402.	Phenol (0.58)	m-Nitrophenol (0.22)
403.	Phenol (0.58)	p-Nitrophenol (0.20)
404.	Phenol (0.58)	Quinol (0.14)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
405.	8-Hydroxyquinoline (0.03)	α -Naphthol (0.52)
406.	p-Chlorophenol (0.46)	p-Nitrophenol (0.20)
407.	Pyrogallol (0.03)	α -Naphthol (0.52)
408.	Pyrogallol (0.03)	B-Naphthol (0.43)
409.	Gallic acid (0.00)	α -Naphthol (0.52)
410.	1-Nitroso-2-Naphthol (0.03)	α -Naphthol (0.52)
411.	Quinhydrone (0.12)	α -Naphthol (0.52)
412.	4-(4-Nitrophenyl azo) Resorcinol (0.00)	Thymol (0.82)
413.	Pentahydroxy flavone (0.00)	Thymol (0.82)
414.	Phenyl fluorone (0.00)	Thymol (0.82)
415.	Bromo cresol green (0.00)	B-Naphthol (0.43)
	SEPARATIONS IN TOLUENE : CHLOROFORM : ACETONE (35 : 30 : 35)	
416.	O-Aminophenol (0.75)	O-Nitrophenol (0.47)
417.	O-Aminophenol (0.75)	m-Nitrophenol (0.25)
418.	O-Aminophenol (0.75)	p-Nitrophenol (0.14)
419.	O-Nitrophenol (0.48)	m-Nitrophenol (0.23)
420.	O-Nitrophenol (0.48)	p-Nitrophenol (0.16)
421.	Resorcinol (0.23)	Catechol (0.02)
422.	Gallic acid (0.00)	Resorcinol (0.23)
423.	Catechol (0.02)	Phenol (0.71)
424.	Catechol (0.02)	α -Naphthol (0.66)
425.	B-Naphthol (0.74)	1-Nitroso-2-Naphthol (0.06)
426.	B-Naphthol (0.73)	Quinhydrone (0.13)
427.	B-Naphthol (0.74)	8-Hydroxyquinoline (0.02)
428.	Vanilline (0.20)	Thymol (0.92)
429.	Bromo cresol green (0.00)	Thymol (0.92)
430.	Bromo phenol blue (0.00)	Thymol (0.92)
431.	Phenolphthaline (0.14)	Thymol (0.92)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
432.	4-(4-Nitrophenyl azo) Resorcinol (0.00)	Thymol (0.92)
433.	Pentahydroxy flavone (0.00)	Thymol (0.92)
434.	Phenyl fluorone (0.00)	Thymol (0.92)
435.	Phenol (0.71)	Gallic acid (0.00)
436.	Phenol (0.71)	Pyrogallol (0.04)
437.	Picric acid (0.00)	Thymol (0.92)
438.	Picric acid (0.00)	α-Naphthol (0.66)
439.	O-Cresol (0.80)	Bromo cresol green (0.00)
440.	m-Cresol (0.74)	Bromo cresol green (0.00)
441.	8-Hydroxyquinoline (0.02)	α-Naphthol (0.66)
442.	O-Chlorophenol (0.12)	p-Chlorophenol (0.55)
443.	1-Nitroso-2-Naphthol (0.06)	α-Naphthol (0.66)
444.	Quinhydrone (0.13)	α-Naphthol (0.66)
	SEPARATIONS IN BUTANOL : BENZENE : ACETIC ACID (55 : 40 : 5)	
445.	Resorcinol (0.80)	Catechol (0.54)
446.	Resorcinol (0.80)	Pyrogallol (0.20)
447.	Resorcinol (0.80)	Phloroglucinol (0.59)
448.	Catechol (0.54)	Pyrogallol (0.20)
449.	B-Naphthol (0.92)	8-Hydroxyquinoline (0.19)
450.	1-Nitroso-2-Naphthol (0.60)	B-Naphthol (0.92)
451.	Vanilline (0.78)	Gallic acid (0.07)
452.	Vanilline (0.78)	Pyrogallol (0.20)
453.	Thymol (0.94)	Bromo cresol green (0.02)
454.	Thymol (0.94)	Bromo phenol blue (0.02)
455.	4-(4-Nitrophenylazo) Resorcinol (0.70)	Thymol (0.94)
456.	Pentahydroxy flavone (0.07)	Thymol (0.94)
457.	Phenyl fluorone (0.00)	Thymol (0.94)

(Table V continued)

Sl. No.	Separation	
	Of R_F	From R_F
458.	Phenol (0.83)	Catechol (0.54)
459.	Pyrogallol (0.20)	Phenol (0.83)
460.	Phenol (0.83)	Phloroglucinol (0.58)
461.	Picric acid (0.05)	Phenol (0.82)
462.	Picric acid (0.05)	Vanilline (0.78)
463.	Picric acid (0.05)	Thymol (0.94)
464.	Quinol (0.72)	Pyrogallol (0.20)
465.	8-Hydroxyquinoline (0.19)	Quinol (0.72)
466.	Bromo cresol green (0.02)	O-Cresol (0.82)
467.	Bromo cresol green (0.02)	m-Cresol (0.79)
468.	8-Hydroxyquinoline (0.19)	1-Nitroso-2-Naphthol (0.60)
469.	8-Hydroxyquinoline (0.19)	Quinhydrone (0.89)
470.	O-Chlorophenol (0.30)	p-Chlorophenol (0.90)
471.	Phloroglucinol (0.59)	Pyrogallol (0.20)
472.	Gallic acid (0.07)	Phloroglucinol (0.59)
473.	1-Nitroso-2-Naphthol (0.60)	Quinhydrone (0.89)
474.	α -Naphthol (0.86)	Gallic acid (0.07)
475.	α -Naphthol (0.86)	8-Hydroxyquinoline (0.19)
476.	Phenolphthaline (0.86)	Bromophenol blue (0.02)
477.	Phenolphthaline (0.86)	Bromo cresol green (0.02)
478.	Phenyl fluorone (0.00)	Phenolphthaline (0.85)
479.	Pentahydroxy flavone (0.07)	Phenolphthaline (0.85)
480.	Quinhydrone (0.89)	8-Hydroxy-7-Iodoquinoline-5-Sulphonic acid (0.00)

TABLE VI

TERNARY SEPARATIONS ACHIEVED IN VARIOUS SOLVENT SYSTEMS

Sl. No.	Separation		
	Of R_F	From R_F	Solvent
1.	B-Naphthol (0.00)	α-Naphthol (0.51) and Quinhydrone (0.78)	Conductivity water
2.	Catechol (0.05)	Resorcinol (0.70) and p-Nitrophenol (0.43)	-do-
3.	Catechol (0.3)	Phloroglucinol (0.34) and Resorcinol (0.77)	Ethyl alcohol
4.	Picric acid (0.06)	p-Nitrophenol (0.43) and m-Nitrophenol (0.68)	-do-
5.	Bromo cresol green (0.00)	Vanilline (0.36) and Thymol (0.84)	-do-
6.	B-Naphthol (0.79)	1-Nitroso-2-Naphthol (0.03) and m-Nitrophenol (0.27)	Ethyl acetate
7.	Resorcinol (0.43)	4-(4-Nitrophenyl azo) Resorcinol (0.87) and Catechol (0.02)	-do-
8.	α-Naphthol (0.88)	Quinol (0.66) and Bromo cresol green (0.00)	Acetone
9.	Quinhydrone (0.64)	Phloroglucinol (0.22) and Gallic acid (0.00)	-do-
10.	Picric acid (0.00)	m-Nitrophenol (0.27) and α-Naphthol (0.80)	1,4-Dioxane
11.	Catechol (0.02)	Quinol (0.57) and α-Naphthol (0.79)	-do-

(Table VI continued)

Sl. No.	Separation		
	Of R_F	From R_F	Solvent
12.	Pyrogallol (0.04)	Phloroglucinol (0.40) and Resorcinol (0.74)	Methanol
13.	Phenol (0.84)	O-Nitrophenol (0.16) and m-Nitrophenol (0.57)	-do-
14.	Bromo cresol green (0.00)	Phenolphthaline (0.44) and Thymol (0.88)	-do-
15.	Bromo phenol blue (0.00)	Phenolphthaline (0.44) and Thymol (0.87)	-do-
16.	Catechol (0.02)	m-Nitrophenol (0.58) and Thymol (0.87)	-do-
17.	Gallic acid (0.00)	p-Chlorophenol (0.44) and O-Chlorophenol (0.74)	Butanone-2
18.	Vanilline (0.06)	Resorcinol (0.29) and Thymol (0.90)	-do-
19.	Pyrogallol (0.03)	Resorcinol (0.29) and ∝-Naphthol (0.81)	-do-
20.	B-Naphthol (0.00)	p-Nitrophenol (0.33) and Picric acid (0.62)	0.1M Acetic acid
21.	Pyrogallol (0.11)	Vanilline (0.54) and Quinhydrone (0.80)	-do-
22.	Pyrogallol (0.08)	Vanilline (0.43) and Phloroglucinol (0.68)	0.1M DMSO
23.	Quinhydrone (0.76)	Vanilline (0.48) and 1-Nitroso-2-Naphthol (0.04)	0.1M Pyridine

(Table VI continued)

Sl. No.	Separation		
	Of R_F	From R_F	Solvent
24.	Gallic acid (0.03)	p-Nitrophenol (0.24) and m-Nitrophenol (0.58)	0.1M Pyridine
25.	Catechol (0.04)	4-(4-Nitrophenyl azo) Resorcinol (0.54) and Resorcinol (0.74)	1.0M Pyridine
26.	4-(4-Nitrophenyl azo) Resorcinol (0.23)	Picric acid (0.41) and Resorcinol (0.76)	1% SDS
27.	Gallic acid (0.00)	B-Naphthol (0.42) and Thymol (0.82)	Butanone-2 : Cyclohexane (25:75)
28.	α-Naphthol (0.53)	O-Aminophenol (0.31) and Gallic acid (0.03)	-do-
29.	Pyrogallol (0.20)	Catechol (0.52) and Quinol (0.75)	Butanol : Benzene : Acetic acid (55 : 40 : 5)
30.	Quinhydrone (0.89)	1-Nitroso-2-Naphthol (0.60) and 8-Hydroxyquinoline (0.19)	-do-
31.	B-Naphthol (0.92)	1-Nitroso-2-Naphthol (0.60) and 8-Hydroxyquinoline (0.20)	-do-
32.	Resorcinol (0.80)	Catechol (0.54) and Pyrogallol (0.20)	-do-
33.	Gallic acid (0.07)	O-Chlorophenol (0.31) and p-Chlorophenol (0.89)	-do-

(Table VI continued)

Sl. No.	Separation		
	Of R_F	From R_F	Solvent
34.	Bromo cresol green (0.02)	Phloroglucinol (0.59) and ∝-Naphthol (0.86)	Butanol : Benzene : Acetic acid (55 : 40 : 5)
35.	O-Aminophenol (0.75)	O-Nitrophenol (0.47) and Catechol (0.02)	Toluene : Chloroform : Acetone (35 : 30 : 35)
36.	1-Nitroso-2-Naphthol (0.04)	Resorcinol (0.27) and B-Naphthol (0.74)	-do-
37.	Quinol (0.58)	Phloroglucinol (0.26) and Pyrogallol (0.03)	Methanol : Toluene : (1 : 1)
38.	Gallic acid (0.02)	Phloroglucinol (0.27) and Resorcinol (0.59)	-do-
39.	Catechol (0.02)	Phloroglucinol (0.27) and Quinhydrone (0.63)	-do-

TABLE VII

QUATERNARY SEPARATIONS ACHIEVED IN VARIOUS SOLVENT SYSTEMS

Sl. No.	Separation		
	Of R_F	From R_F	Solvent
1.	1-Nitroso-2-Naphthol (0.04)	O-Aminophenol (0.36), ∝-Naphthol (0.57) and Quinhydrone (0.78)	Conductivity water
2.	Pyrogallol (0.03)	Resorcinol (0.70), O-Aminophenol (0.86) and Thymol (0.93)	Butanone-2
3.	Gallic acid (0.00)	Phloroglucinol (0.36), Quinhydrone (0.64) and Thymol (0.79)	Methanol
4.	Catechol (0.02)	O-Nitrophenol (0.23), Resorcinol (0.49) and O-Aminophenol (0.89)	1,4-Dioxane
5.	8-Hydroxyquinoline (0.03)	Phloroglucinol (0.24), Quinhydrone (0.63) and ∝-Naphthol (0.88)	Acetone
6.	B-Naphthol (0.03)	∝-Naphthol (0.32), O-Nitrophenol (0.55) and Resorcinol (0.78)	1% SDS
7.	Catechol (0.06)	O-Aminophenol (0.41), Quinol (0.86) and 4-(4-Nitrophenyl azo) Resorcinol (0.63)	0.1N Acetic acid : 1,4-Dioxane (1 : 1)
8.	Picric acid (0.05)	p-Nitrophenol (0.33), m-Nitrophenol (0.58) and ∝-Naphthol (0.74)	Methanol : Toluene (1 : 1)

DISCUSSION

Phenols were also chromatographed on Silica gel G thin layers and developed in almost all the solvents used for Alumina coated plates. On comparison, it was found that different phenols are better separable on Alumina layer than on Silica gel layer. On Alumina layer the spots were compact, distinct and easily detected while on the silica gel layer the spots were irregular with tailing and the detection was less distinct. The result of R_F values of different phenols on alumina layers and silica gel layers are shown in tables II and III respectively. It can be seen from the tables that silica coated plates show poor resolution in almost all the solvents systems tried. Alumina layers, however, exhibit greater resolution and offer better possibility of separations of various phenols.

Results given in table IV reveal that the R_F values of phenols on alumina loaded plates in aqueous ammonia follow a definite trend. Plots of R_F against molar concentration of ammonium hydroxide as shown in Figure 1 (a - f) are generally straight lines and R_F values increases as the concentration of ammonium hydroxide increases. This fact is owed to the weakly acidic nature of phenols which in ammonium hydroxide media are more ionised as the concentration of ammonium hydroxide increases.

R_F values of phenols remain quite low in most of the cases when conductivity water, benzene, carbon disulphide, and toluene

were used as developing solvents which can be seen in table II.

The plots of R_F vs. number of hydroxy groups keeping number of benzene rings constant, as shown in Figure 2 (a - h) are plotted for O-Aminophenol, Resorcinol, Pyrogallol, Phenol, Quinol, and Gallic acid in different developing solvent systems. From the figures it can be inferred that R_F values of phenols having one hydroxy group is greater than the phenol having two hydroxy groups which in turn is greater than the one with three hydroxy groups.

The plots of R_F vs. number of benzene rings as shown in Figure 3 (a - j) show when number of hydroxy groups are kept constant. R_F values increases as the number of benzene rings increases in phenols. Alumina works as a good adsorbent hence its affinity should be greater for the phenol which can furnish greater number of hydrogen ions. So the phenols like pyrogallol are more strongly adsorbed than resorcinol and thymol. As a result of R_F values of trihydroxy phenols are the least in the comparison of dihydroxy and monohydroxy phenols.

On the basis of difference in R_F values a number of important separations were tried and those practically achieved are given in tables V, VI and VII.

It will be interesting to plot the quaternary separations diagramatically as represented in Figure 4, which gives a view to confirm quite sharp separations.

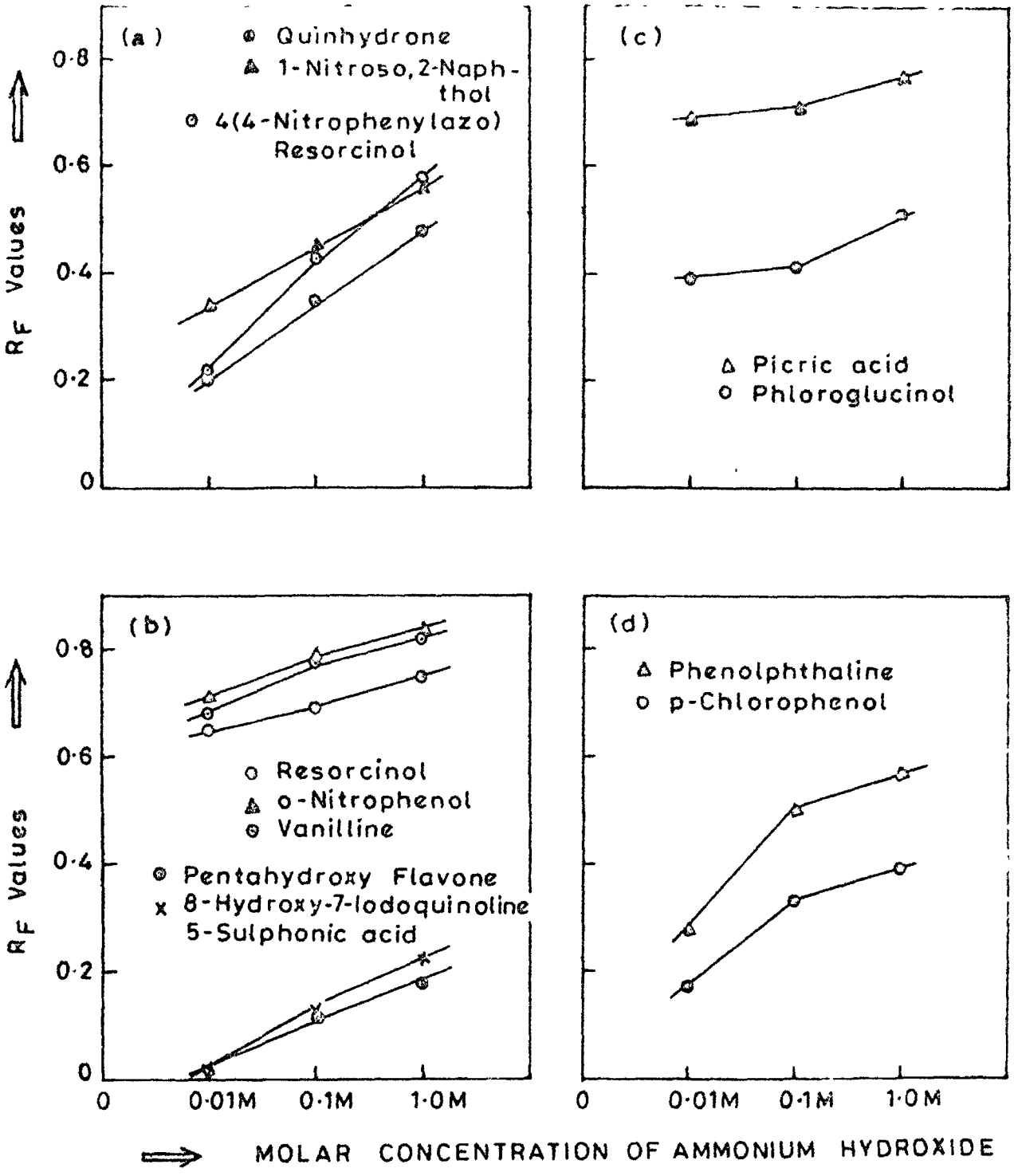

FIGURE 1(a-d) PLOTS OF R_F AGAINST MOLAR CONCENTRATION OF AMMONIUM HYDROXIDE

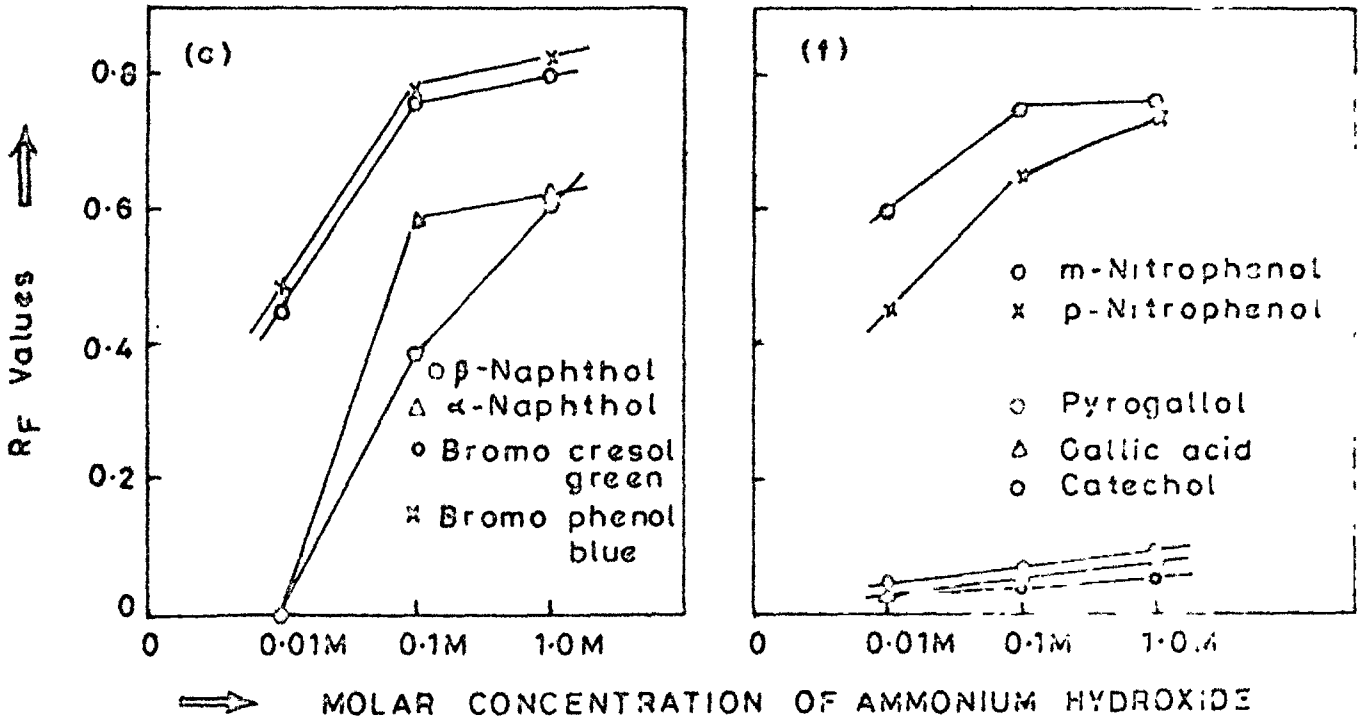

FIGURE 1(c-f) PLOTS OF R_F AGAINST MOLAR CONCENTRATION OF AMMONIUM HYDROXIDE

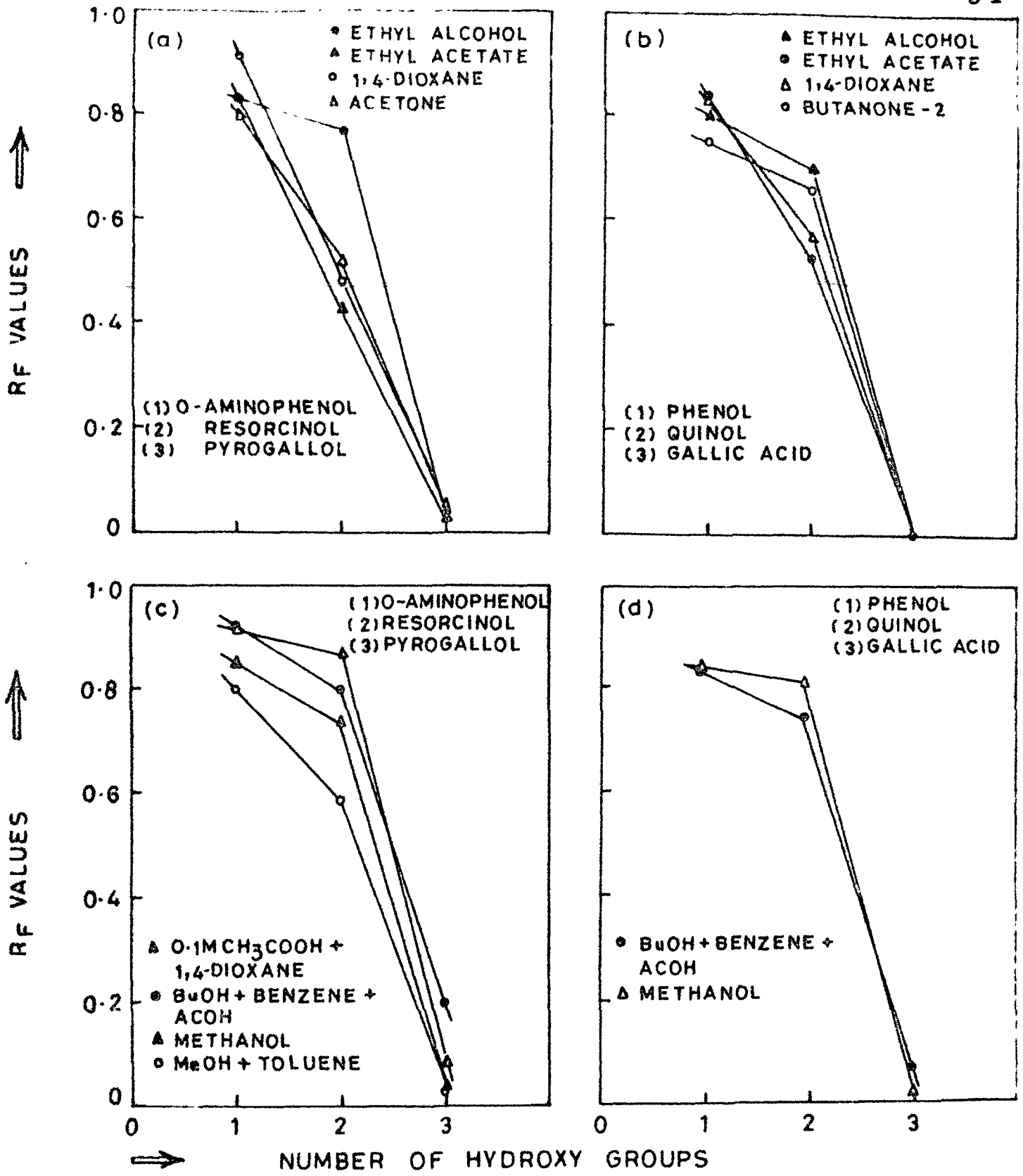

FIGURE 2(a-d) PLOTS OF R_F VS. NUMBER OF HYDROXY GROUPS
(NUMBER OF BENZENE RING REMAINS CONSTANT)
i.e. ONE BENZENE RING PHENOLS

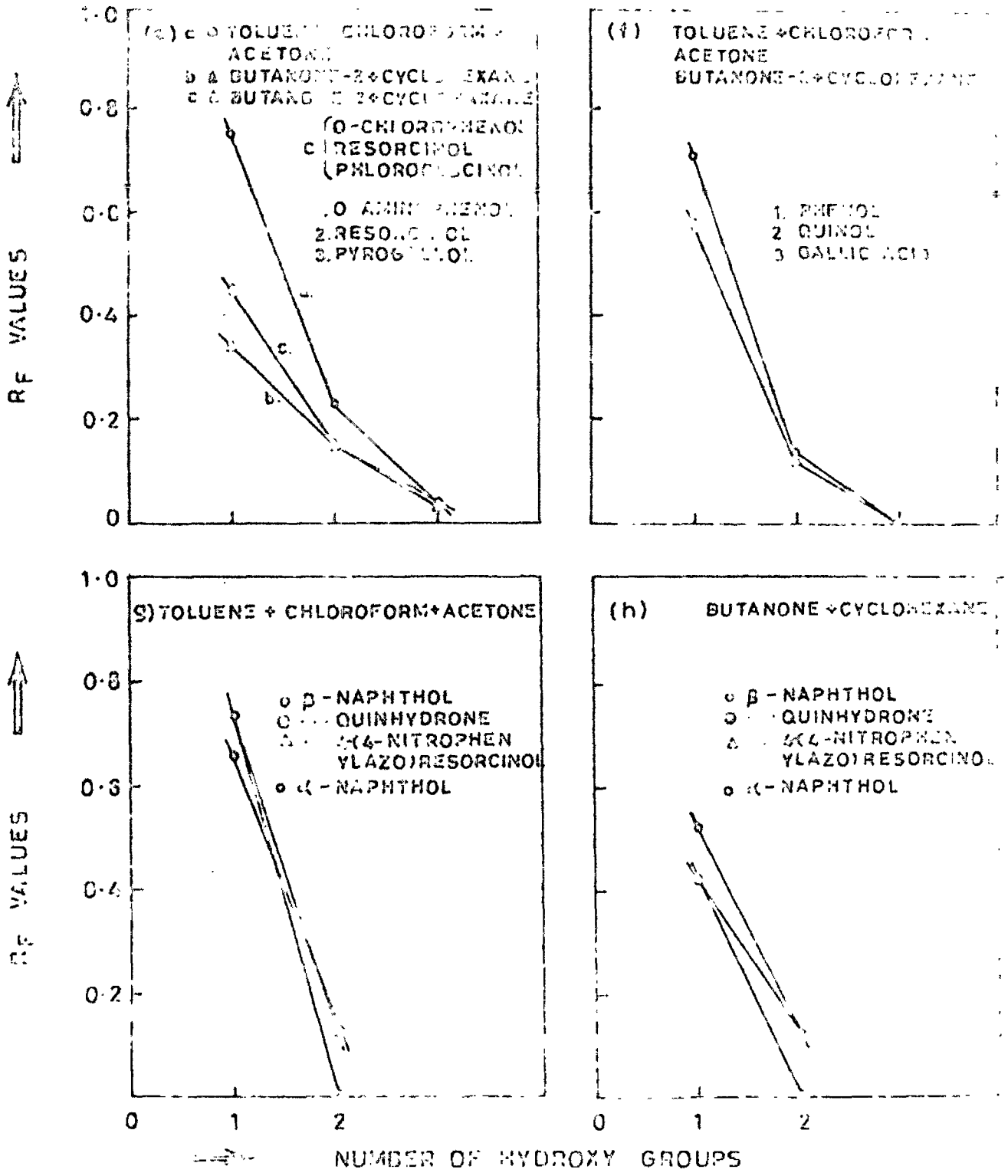

FIGURE 2(e-h) PLOTS OF R_F VS. NUMBER OF HYDROXY GROUPS
(NUMBER OF BENZENE RING REMAINS CONSTANT)
e-h. ONE BENZENE RING PHENOLS

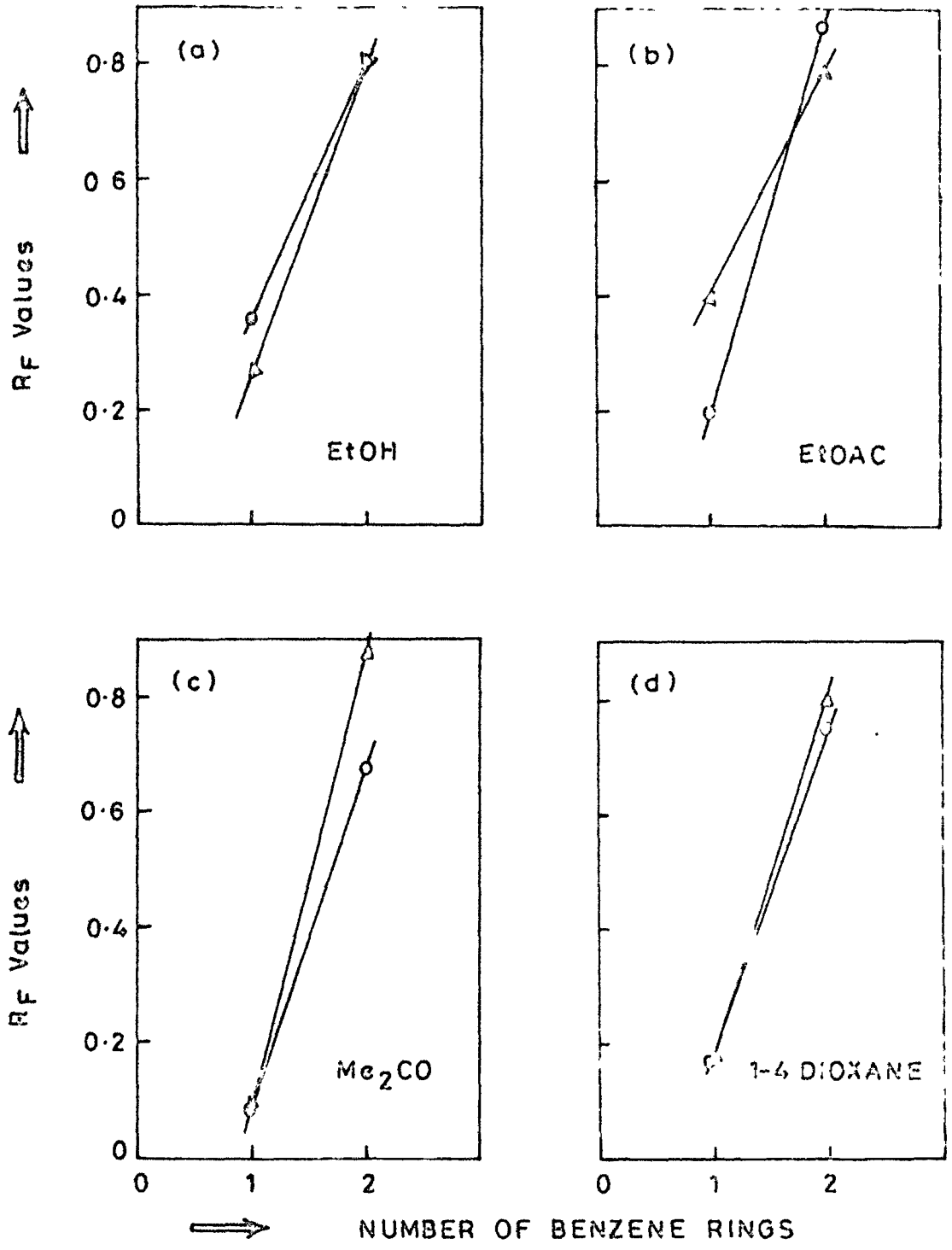

FIGURE 3(a-d) PLOTS OF R_F AGAINST NUMBER OF BENZENE RINGS.
(— OH GROUPS REMAINS CONSTANT)

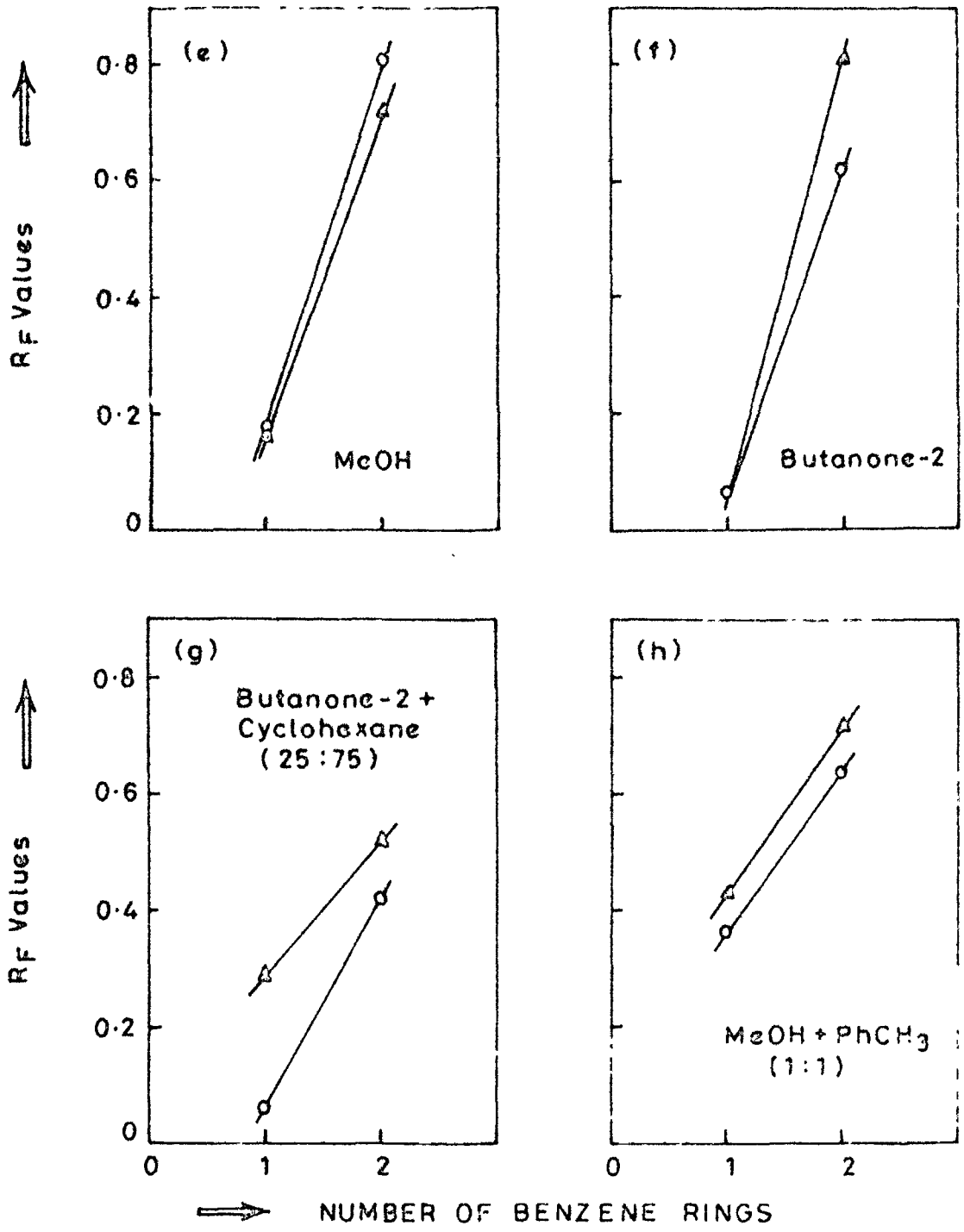

FIGURE 3(e-h) PLOTS OF R_F AGAINST NUMBER OF BENZENE RINGS.
(-OH GROUPS REMAINS CONSTANT)

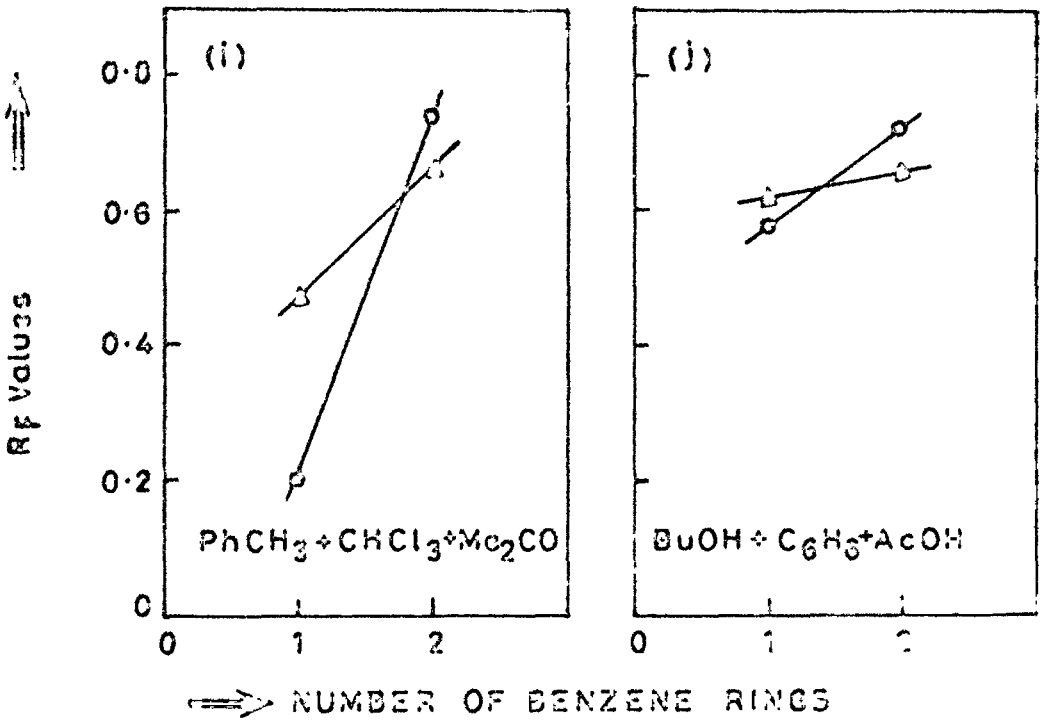

FIGURE 3 (i-j) PLOTS OF R_f AGAINST NUMBER OF BENZENE RINGS.
(—OH GROUPS REMAINS CONSTANT)

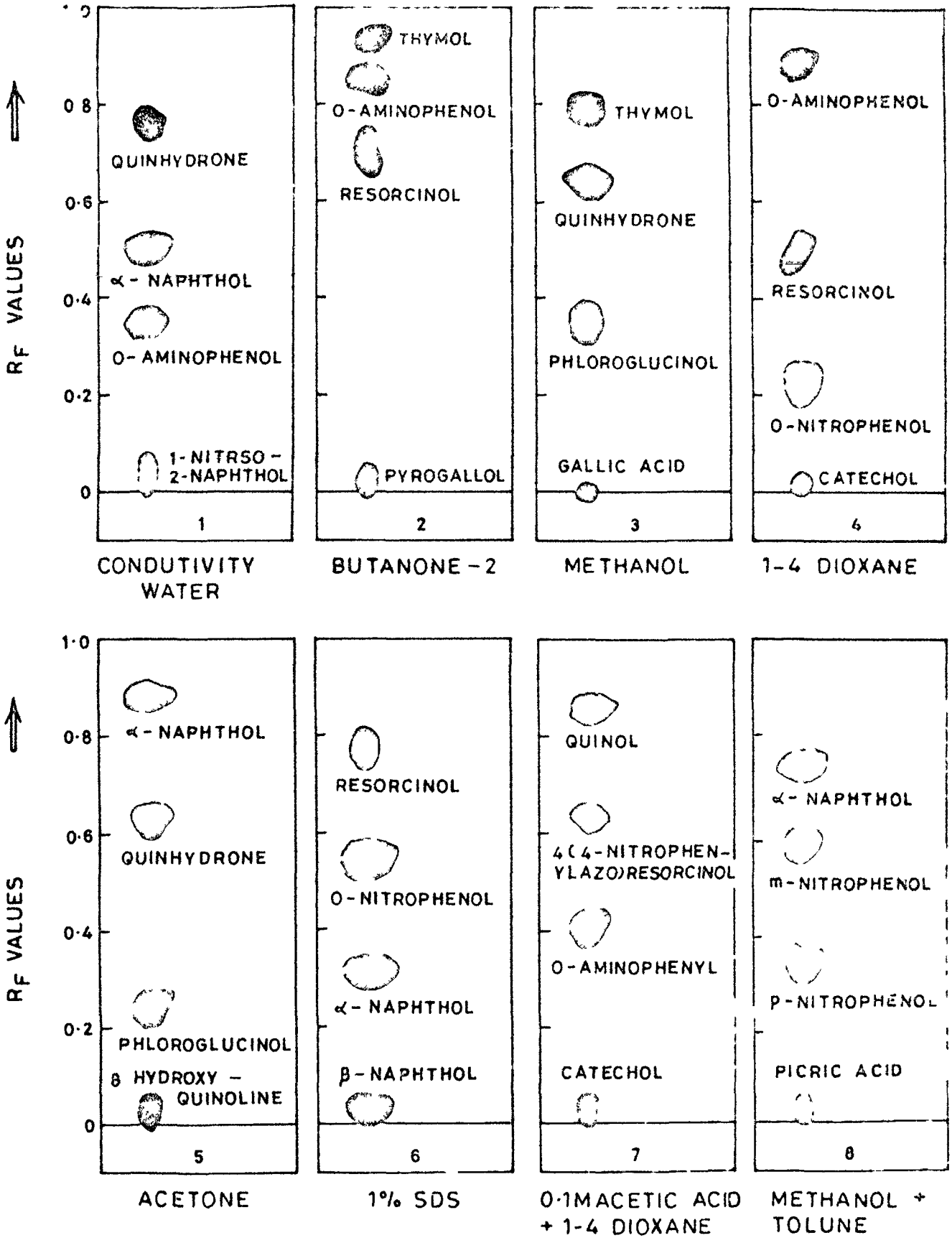

FIG 4 DIAGRAMATIC REPRESENTATION OF QUATERNARY SEPARATIONS ACHIEVED IN DIFFERENT SOLVENT SYSTEMS

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